ISIS

INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

PACKAGING PASSENGERS

THIS BOOK IS THE PROPERTY OF:

STATE ____________
PROVINCE ____________
COUNTY ____________
PARISH ____________
SCHOOL DISTRICT ____________
OTHER ____________

Book No. ________
Enter information in spaces to the left as instructed

ISSUED TO	Year Used	CONDITION ISSUED	CONDITION RETURNED

PUPILS to whom this textbook is issued must not write on any page or mark any part of it in any way, consumable textbooks excepted.

1. Teachers should see that the pupil's name is clearly written in ink in the spaces above in every book issued.
2. The following terms should be used in recording the condition of the book: New; Good; Fair; Poor; Bad.

ISIS

INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

PACKAGING PASSENGERS

Ginn and Company

Acknowledgments

In addition to the major effort by the ISIS permanent staff, writing conference participants, and author-consultants (listed on the inside back cover), the following contributed to this minicourse.

Art created by: Arlene Dubanevich, Robert Haydock, Gordon Laite, Jan Pyk

Design and production supplied by: Kirchoff/Wohlberg, Inc.

Photographs supplied by: Donald Huelke, University of Michigan, p. 8 (Figure 2-2); General Motors, pp. 8 (Figure 2-3), 23, 24, 31, 71.

Cover designed by: Martucci Studio

Other acknowledgments: Figure 6-4 "Injuries to Unbelted Drivers" and Figure 6-5 "Injuries to Belted Drivers" on pages 25 and 26 compiled from information furnished by Volvo of America Corporation. Used by permission.

The work presented or reported herein was supported by a grant from the National Science Foundation. However, the opinions expressed herein do not necessarily reflect the position and policy of the National Science Foundation, and no official endorsement by that agency should be inferred.

Ginn and Company
A Xerox Education Company
Home Office: Lexington, Massachusetts 02173
0-663-33761-5

FOREWORD

Evidence has been mounting that something is missing from secondary science teaching. More and more, students are rejecting science courses and turning to subjects that they consider to be more practical or significant. Numerous high school science teachers have concluded that what they are now teaching is appropriate for only a limited number of their students.

As their concern has mounted, many science teachers have tried to find instructional materials that encompass more appropriate content and that allow them to work individually with students who have different needs and talents. For the most part, this search has been frustrating because presently such materials are difficult, if not impossible, to find.

The Individualized Science Instructional System (ISIS) project was organized to produce an alternative for those teachers who are dissatisfied with current secondary science textbooks. Consequently, the content of the ISIS materials is unconventional as is the individualized teaching method that is built into them. In contrast with many current science texts which aim to "cover science," ISIS has tried to be selective and to limit coverage to the topics that we judge will be most useful to today's students.

Obviously the needs and problems of individual schools and students vary widely. To accommodate the differences, ISIS decided against producing tightly structured, pre-sequenced textbooks. Instead, we are generating short, self-contained modules that cover a wide range of topics. The modules can be clustered into many types of courses, and we hope that teachers and administrators will utilize this flexibility to tailor-make curricula that are responsive to local needs and conditions.

ISIS is a cooperative effort involving many individuals and agencies. More than 75 scientists and educators have helped to generate the materials, and hundreds of teachers and thousands of students have been involved in the project's nation-wide testing program. All of the ISIS endeavors have been supported by generous grants from the National Science Foundation. We hope that ISIS users will conclude that these large investments of time, money, and effort have been worthwhile.

Ernest Burkman
ISIS Project
Tallahassee, Florida

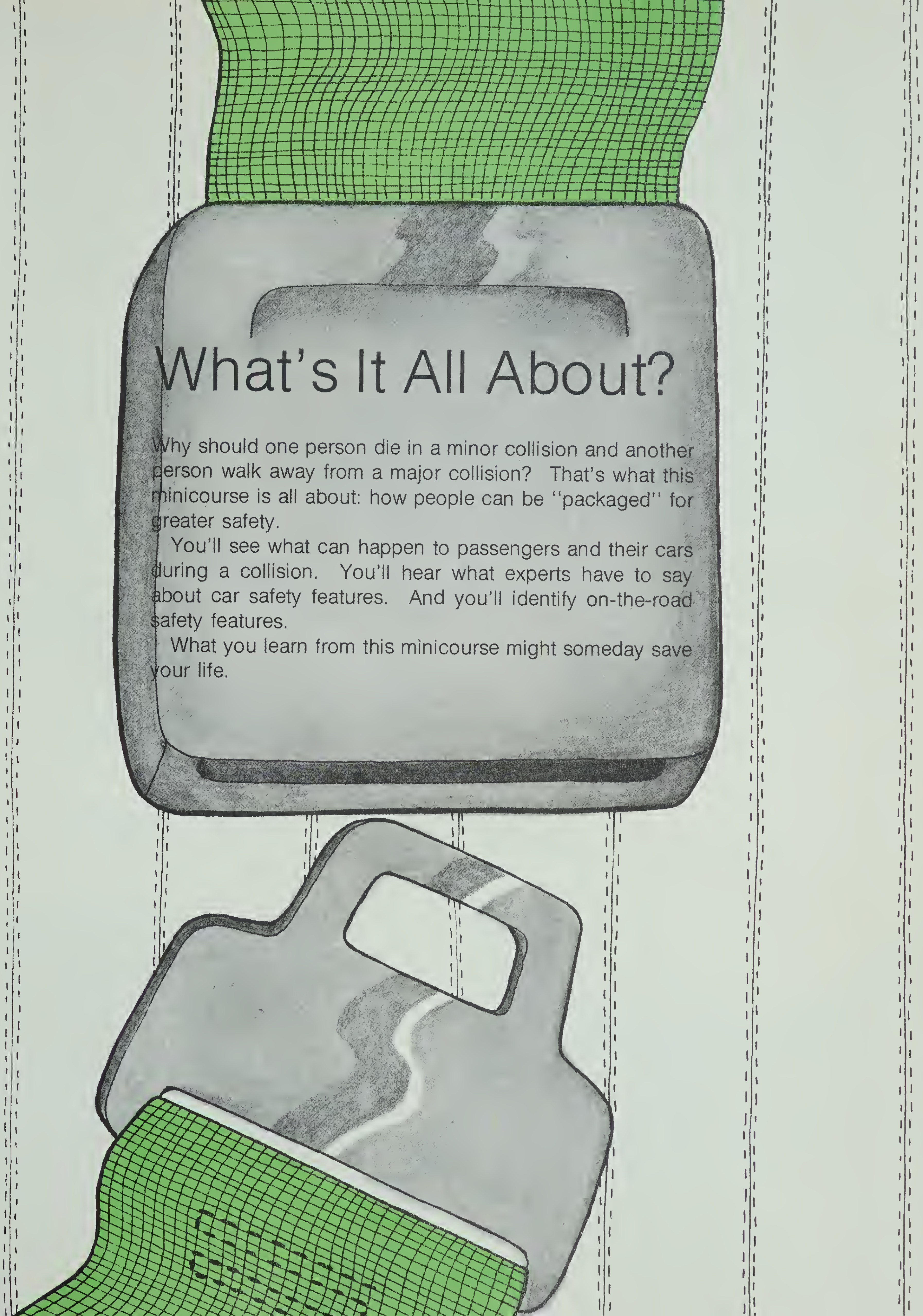
CONTENTS

What's It All About?

Why should one person die in a minor collision and another person walk away from a major collision? That's what this minicourse is all about: how people can be "packaged" for greater safety.

You'll see what can happen to passengers and their cars during a collision. You'll hear what experts have to say about car safety features. And you'll identify on-the-road safety features.

What you learn from this minicourse might someday save your life.



Core

Activity 1 Planning

Activity 3 Page 8

Objective 2: Describe how changes in speed and direction affect a car and its passengers.

Sample Question: A car is going 88 kilometres (55 miles) an hour. A deer suddenly runs in front of the car. The car hits it. Immediately after impact the driver is:

a. thrown backward.
b. thrown forward.
c. not affected since the deer does not weigh much.
d. thrown backward then forward.

Activity 2 Page 5

Objective 1: Tell when the first and second collisions in auto accidents occur, and tell the results of each collision.

Sample Question: Which of the following is the result of a second collision?

a. The bumper is bent.
b. The car hit a tree.
c. The passenger is injured.
d. The car's radiator is cracked.

Activity 4 Page 17

REQUIRED
Design a package to protect an egg from breaking when it is dropped from a height of 6 metres.

Activity 5 Page 18

Objective 3: Describe the safety features of a padded dashboard, a seat belt system, and an air bag system.

Sample Question: True or false? The narrower the material, the better the seat belt will be—as long as the material does not stretch.

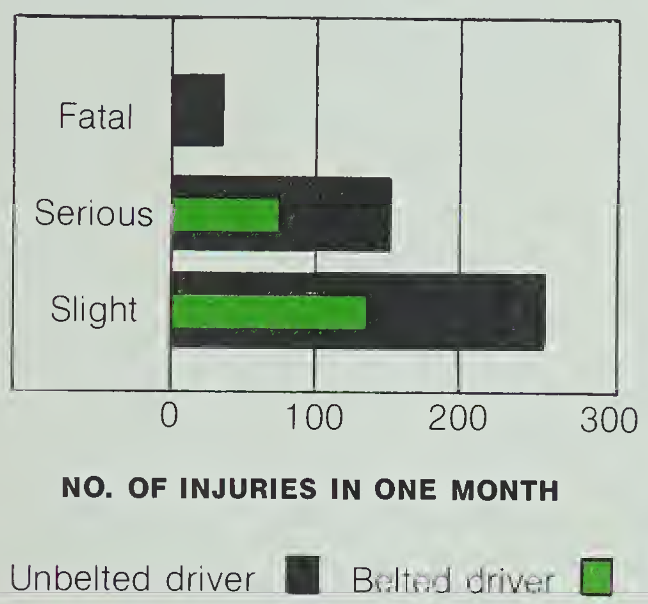
Activity 6 Page 23

Objective 4: Tell when seat belts work best to reduce injuries to passengers in collisions.

Sample Question: Who would be injured more in crashes of 24 to 40 kilometres per hour—belted or unbelted passengers?

Objective 5: Compare the injuries of belted and unbelted passengers reported in graphs or tables.

Sample Question: Look at the graph. Which type of injury happened to unbelted drivers but not to belted drivers? (If you have trouble reading the graph, do Resource Unit 2.*)*



Activity 7 Page 28

Objective 6: Explain how effective air bags are in reducing injuries to passengers.

Sample Question: Air bags are not effective when:

a. *The impact force is spread over a small area.*
b. *The car is hit from behind.*
c. *The car collides head-on with a second object, 2 seconds after the first collision.*
d. *Two cars meet in a head-on collision.*

Answers

1. c 2. b 3. false 4. unbelted passengers 5. fatal injuries 6. b, c

Activity 8 Page 33

Objective 7: Identify statements based on facts, not opinions, in the mandatory seat-belt law debate.

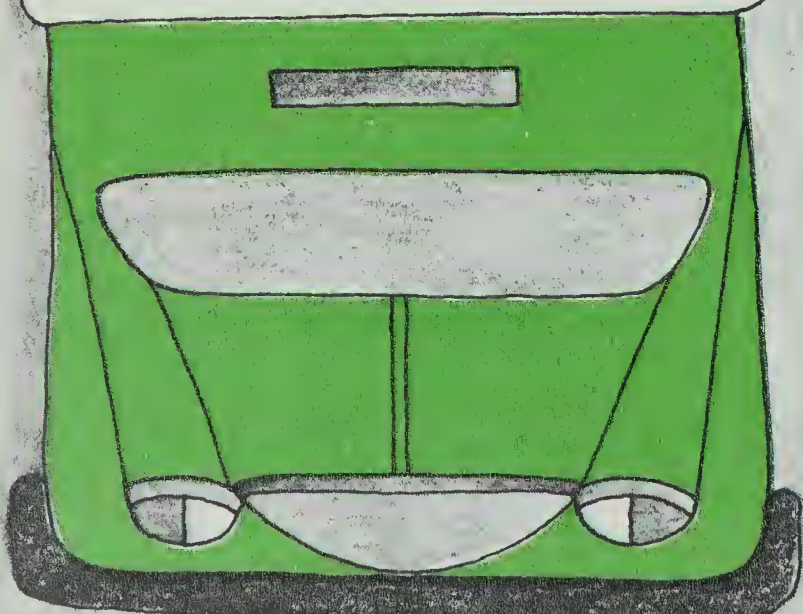
Sample Question: Which of the following arguments is based on fact, not opinion?

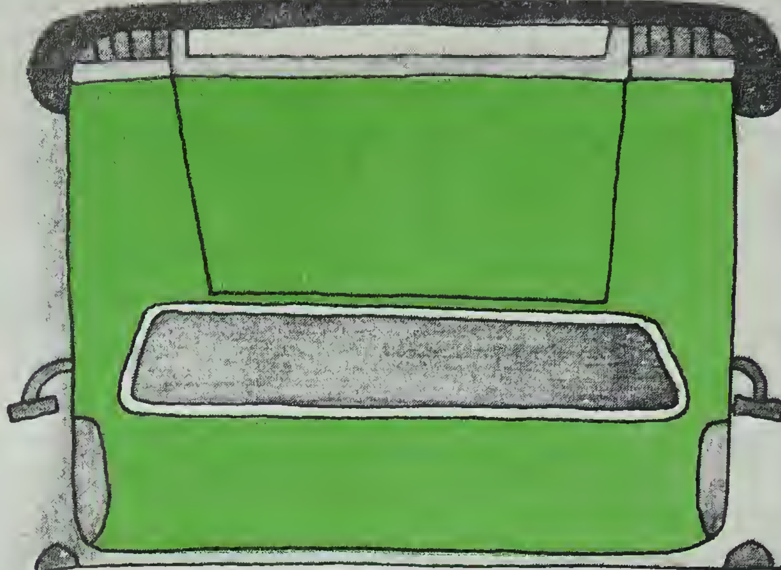
a. Seat-belt laws in other countries have reduced accident injuries.
b. A driver who buckles up is safety conscious.
c. You can't catch the offenders of a seat-belt law.
d. Belted drivers take more risks.

Objective 8: Explain the arguments for and against a seat-belt law.

Sample Question: Which of the following is the strongest argument for the passage of a seat-belt law?

a. Insurance premiums might be lower.
b. Bandages and casts are a nuisance.
c. Unbelted drivers may lose control of their cars during accidents.
d. It's for the common good, based upon accident statistics.





Activity 9 Page 37

Objective 9: Identify ways that energy is conserved during car crashes.

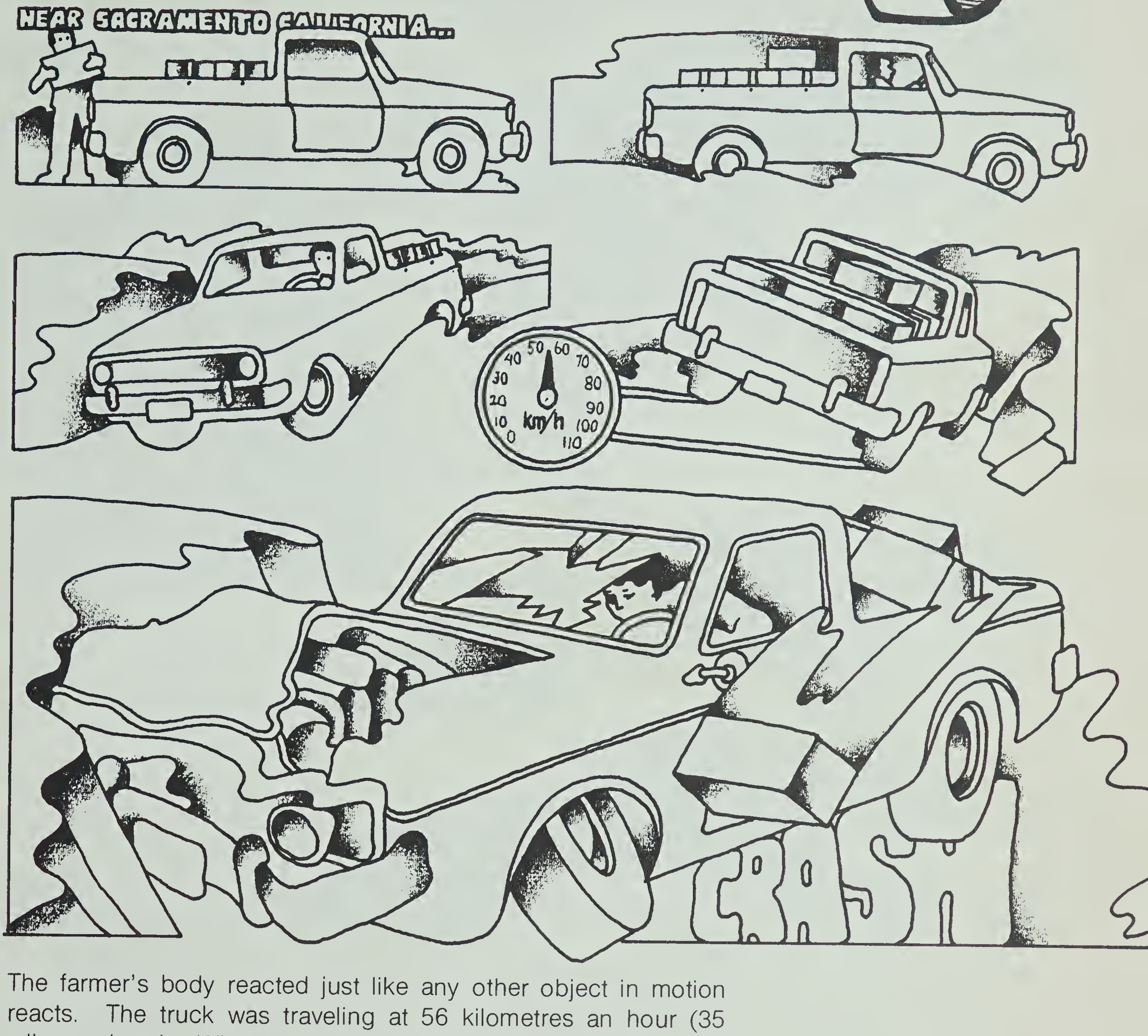
Sample Question: A car collides into a bale of hay. Which statement explains how energy is conserved?

a. The car slows down and the hay starts moving.
b. The car is stopped by the bale of hay.
c. The car keeps right on going at the same speed as before.
d. The weight of the hay makes the car move faster.

Answers
7. a 8. d 9. a

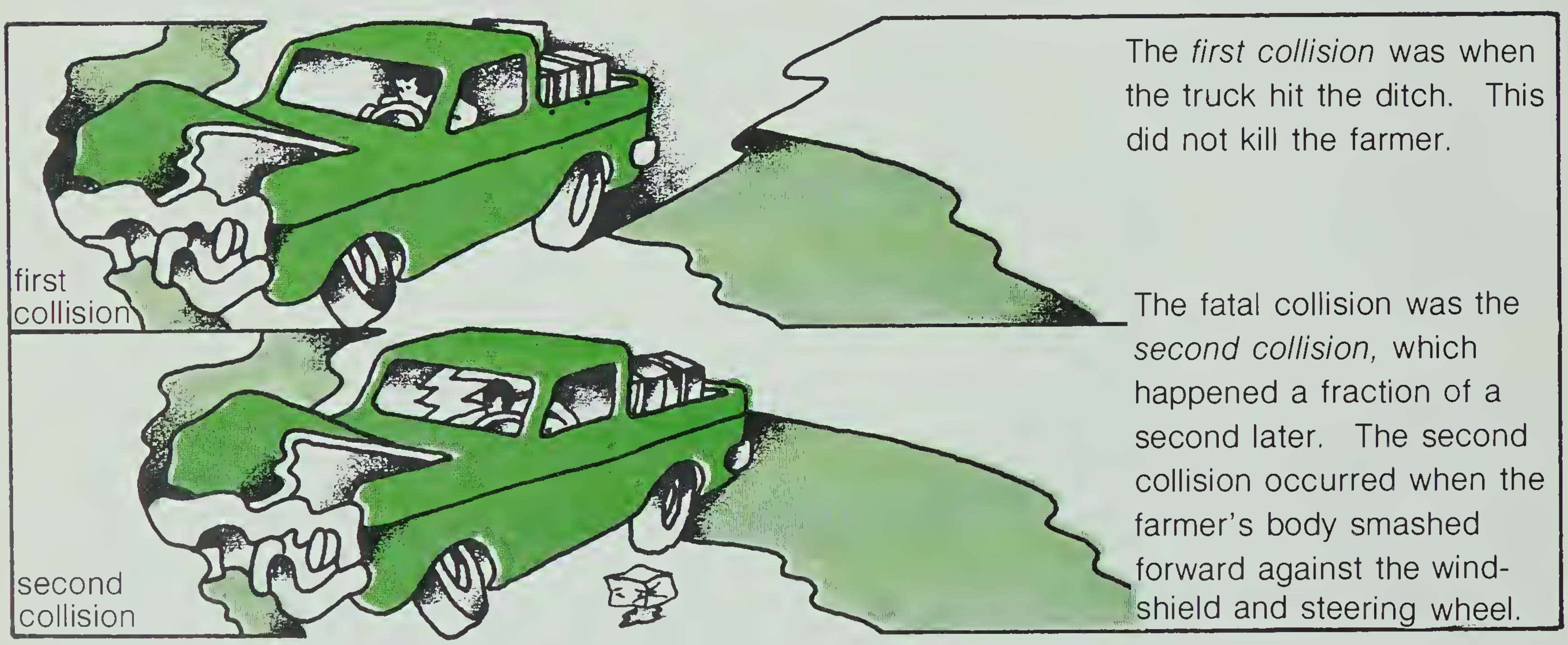
The Second Collision

How can one person walk away from a major collision and another person die in a minor collision? The following story will give you a clue to the answer. (It's a true story.)



The farmer's body reacted just like any other object in motion reacts. The truck was traveling at 56 kilometres an hour (35 miles an hour). When the truck stopped suddenly, the farmer's body kept moving at 56 kilometres an hour. It didn't stop until it crashed into the steering wheel and windshield. This *second collision* killed the farmer.

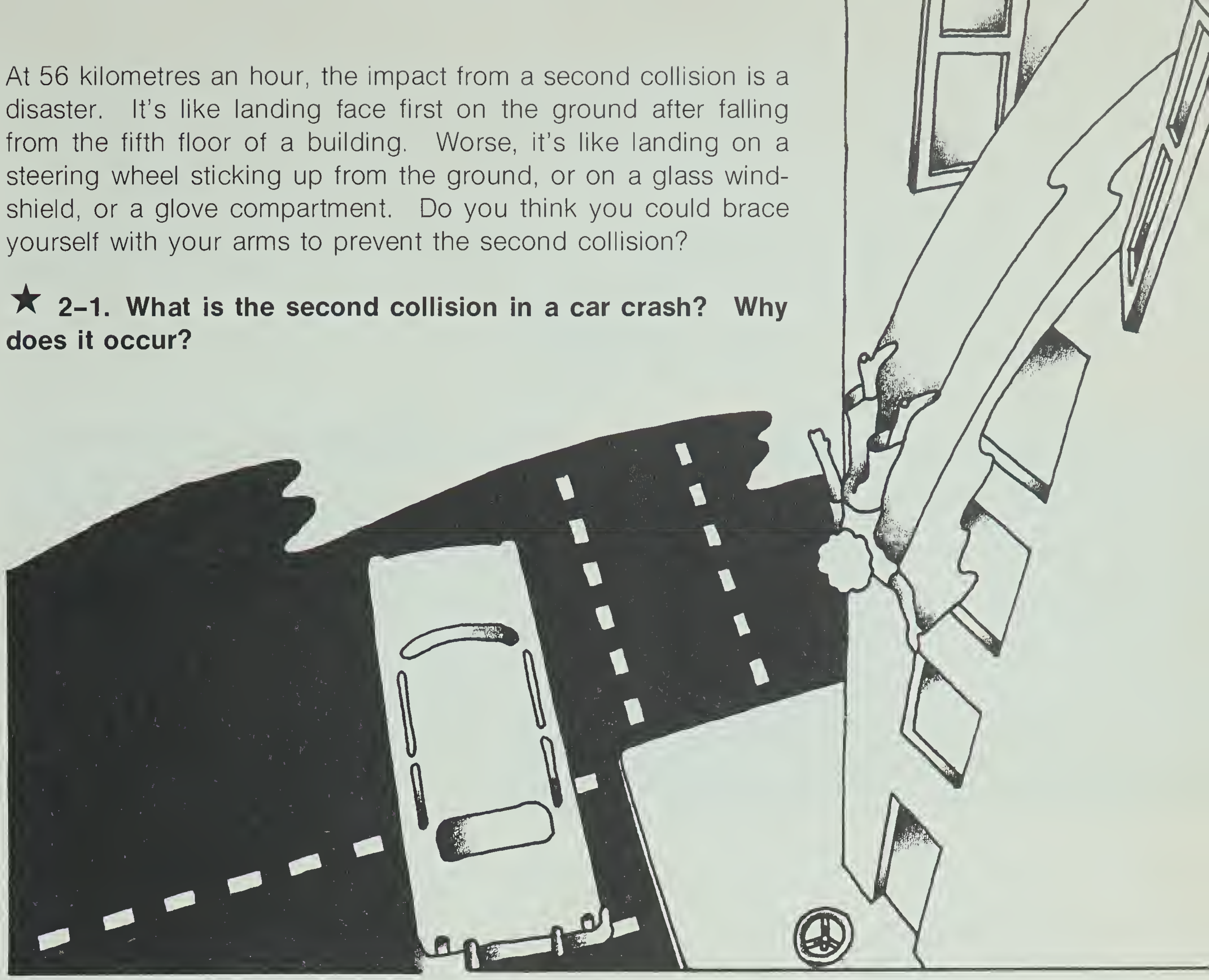
What about the truckload of eggs? The eggs were packed in soft cardboard cartons and piled into crates. The crates were strapped to the back of the truck. Some of the crates were thrown from the truck. The eggs in those crates were smashed. But most of the crates remained strapped to the back of the truck. Of the 1000 dozen eggs, more than 950 dozen were not cracked or broken. In other words, more than 95% of the eggs in the truck were undamaged!



Why was the farmer killed when so many eggs were undamaged? The soft cartons protected the eggs from hitting against each other. The crates were strapped firmly to the truck so that they wouldn't fly off. But the farmer was not "packaged" as carefully. Nothing held him in his seat. He smashed into the front of the truck and was killed.

At 56 kilometres an hour, the impact from a second collision is a disaster. It's like landing face first on the ground after falling from the fifth floor of a building. Worse, it's like landing on a steering wheel sticking up from the ground, or on a glass windshield, or a glove compartment. Do you think you could brace yourself with your arms to prevent the second collision?

★ **2–1. What is the second collision in a car crash? Why does it occur?**



★ **2–2. In Figure 2–1, the cars are about to collide. Car 2 is going to hit Car 1 from the back. Describe the *first* and *second* collisions that will occur.**

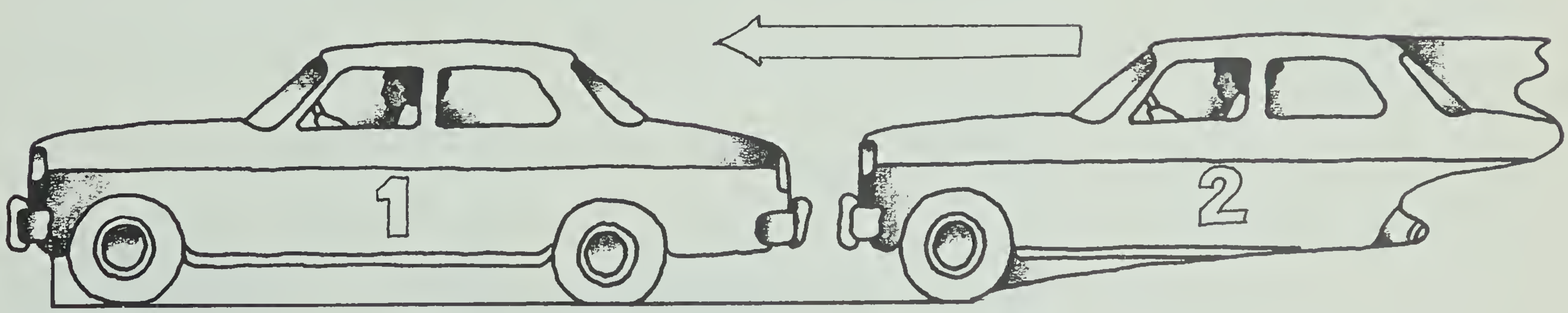


Figure 2–1

✔ 2–3. How would a headrest help the driver or passenger of Car 1?

The photographs in Figures 2–2 and 2–3 show the results of two crashes. In Figure 2–2 the first collision was when the car hit a tree and skidded into another tree. The second collision was when the driver was thrown through the partly opened window. The door was bent outwards by the impact of the driver's body.

In Figure 2–3, a test car is shown after an experimental crash. Two dummies (life-size dolls) are visible. The third dummy had been in the driver's seat and was thrown out of sight under the instrument panel.

Figure 2–2

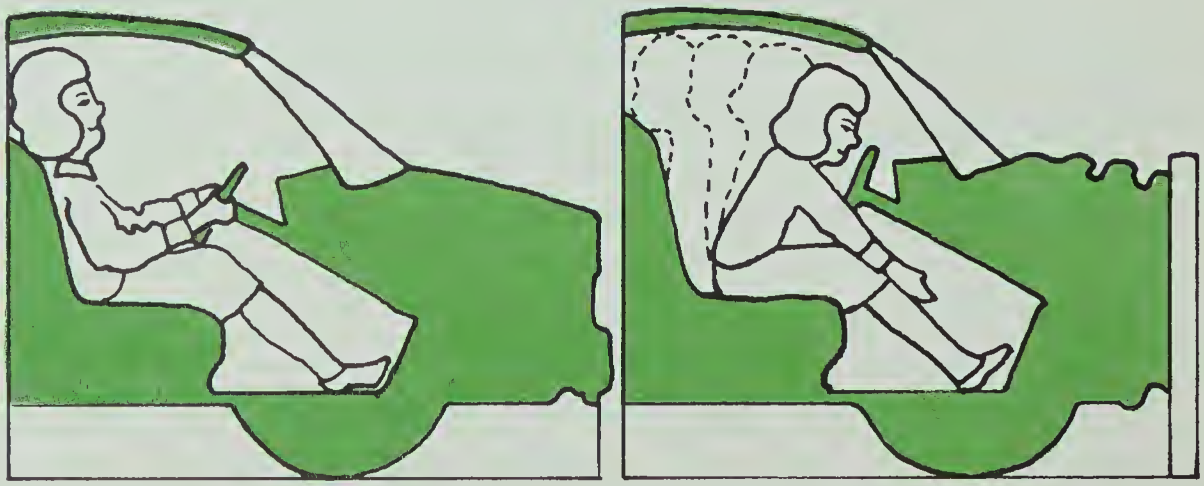
Figure 2–3

★ **2–4. What evidence is there that the driver kept moving after the car stopped in Figure 2–2? In Figure 2–3?**

Sudden Stops Hurt

When you're in a moving car, you travel in the same direction and speed as the car.

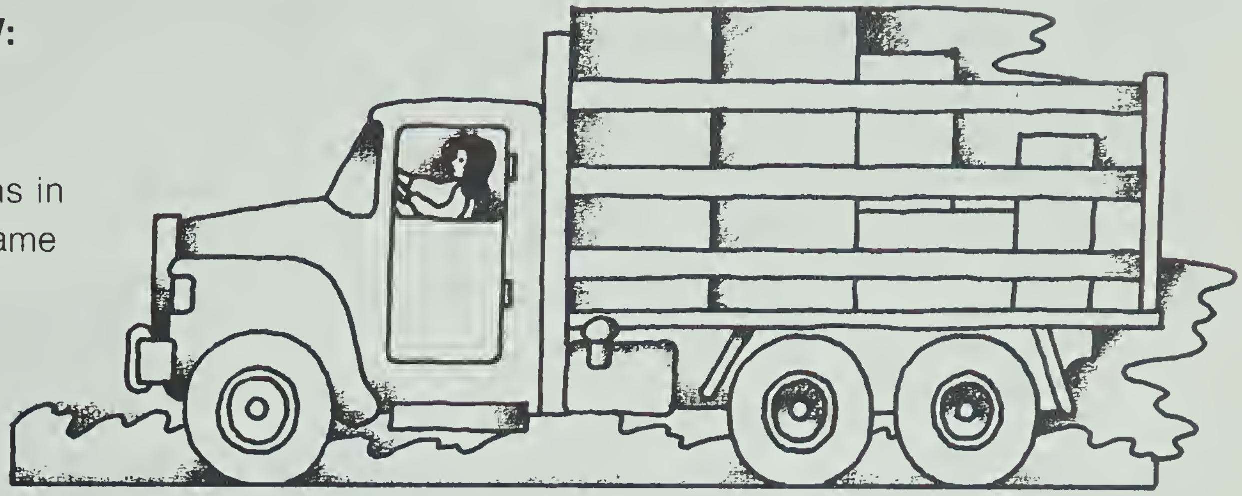
If the car stops suddenly, and you're not restrained (held back), you keep going forward . . . until something stops you.

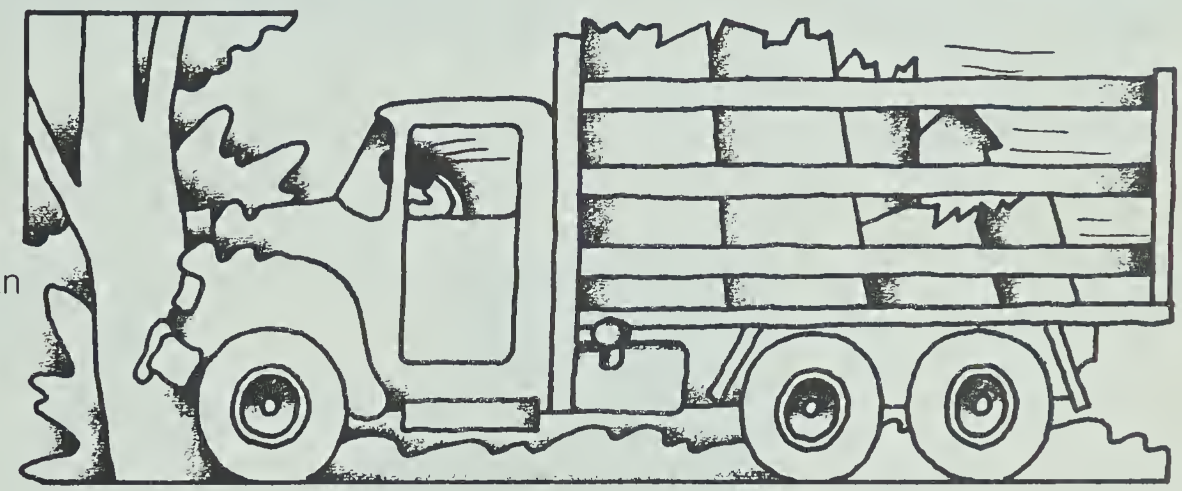


Over 300 years ago, an English scientist, Sir Isaac Newton, described his conclusions about moving objects. These conclusions have been so useful that they are named after Newton. They are called Newton's laws of motion.

NEWTON'S FIRST LAW: PART 1

A body in motion remains in motion, moving at the same speed and in the same direction, . . .



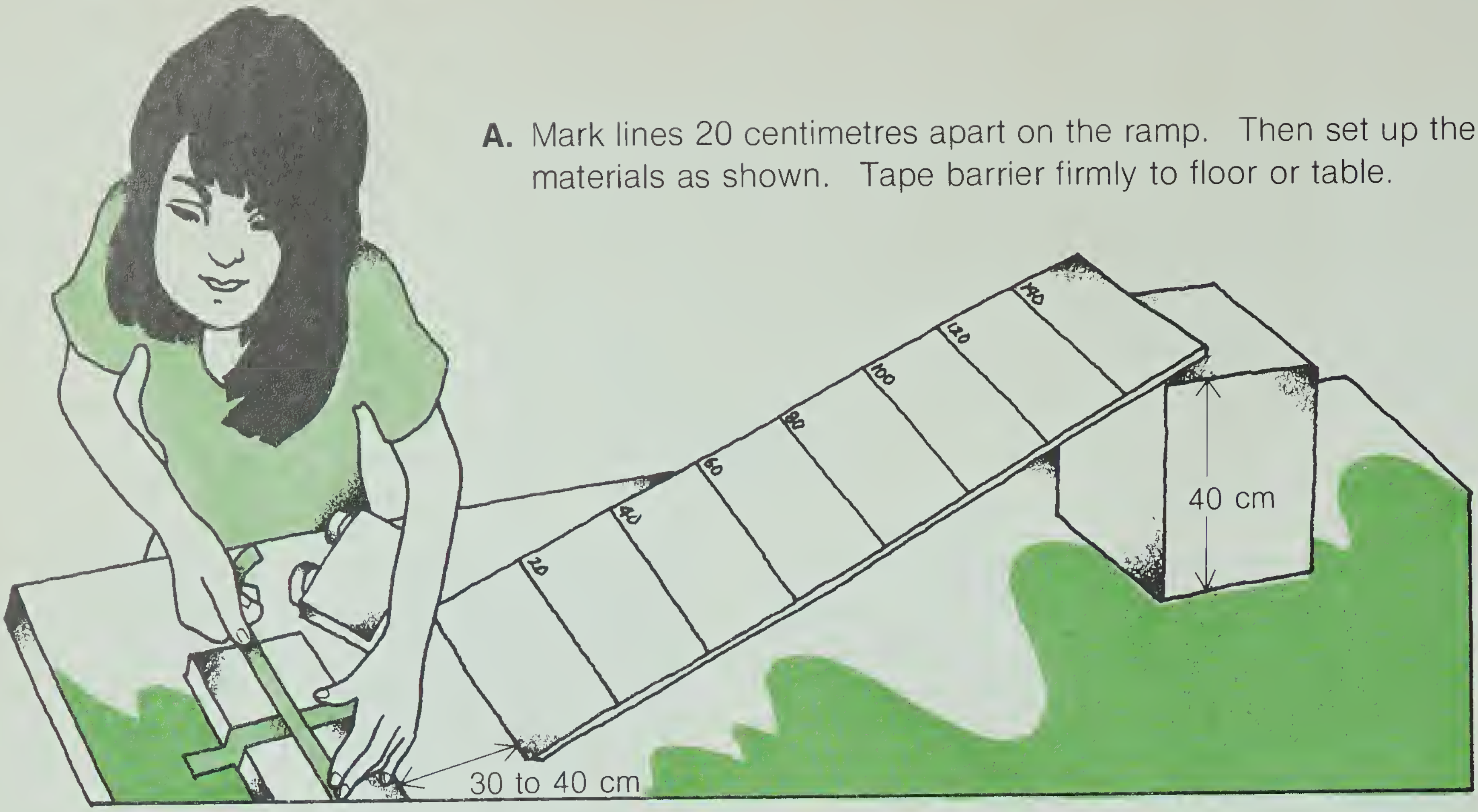


unless acted upon by an outside force.

Newton's first law explains some of the results of a car crash. You'll investigate one of these results here. You'll see what happens to a loose object (driver, passenger, or package) in a moving car after the car stops suddenly. But first see if you can find the average of 10, 15, 7, and 11. There are two investigations in this activity that ask you to find averages. If you need help, do *Resource Unit 1*. (The average for the numbers given is 10.8.)

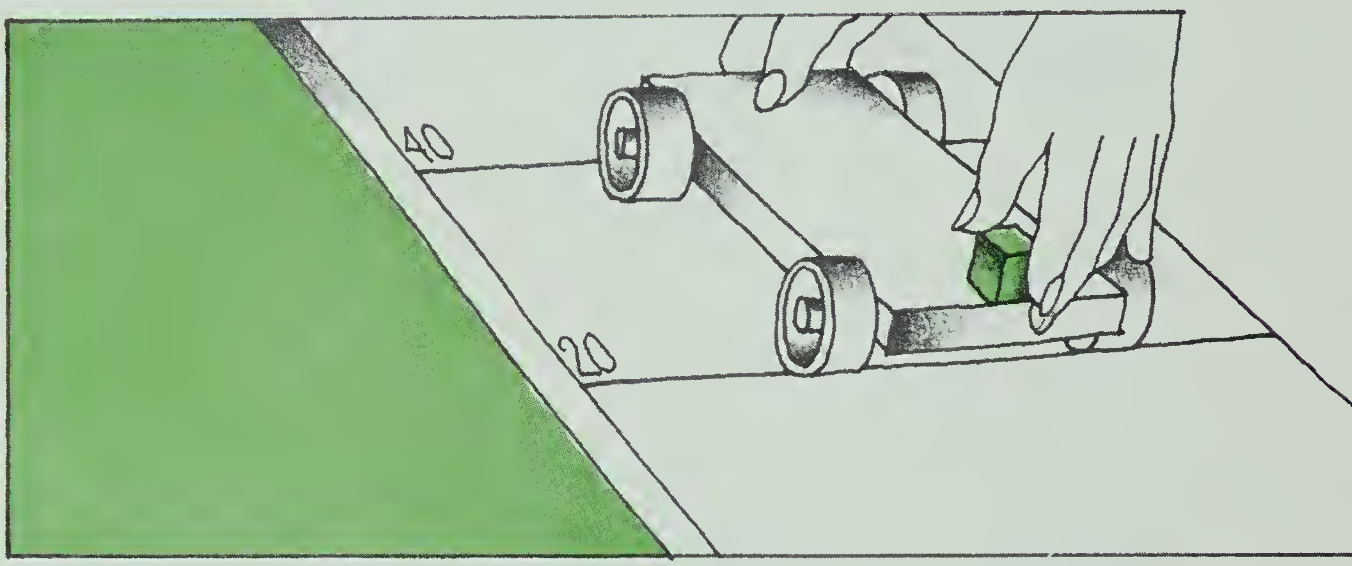
The following materials are needed for this investigation:

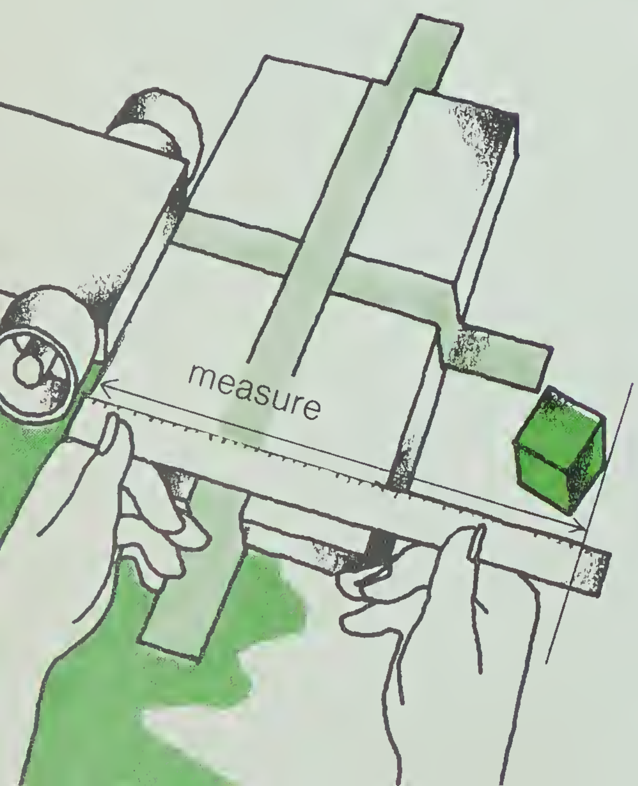
ramp, metal or wooden, about 1.5 m long and 30 cm wide
cardboard carton or stacked bricks, about 40 cm high
dynamics cart
modeling clay to make a cube, 2 cm on a side
small board for barrier
chalk
metric ruler
masking tape



A. Mark lines 20 centimetres apart on the ramp. Then set up the materials as shown. Tape barrier firmly to floor or table.

B. Make a clay cube with sides about 2 centimetres long. Put the cube on the front of the cart. Line up the cart with the 20-centimetre mark. Release the cart.





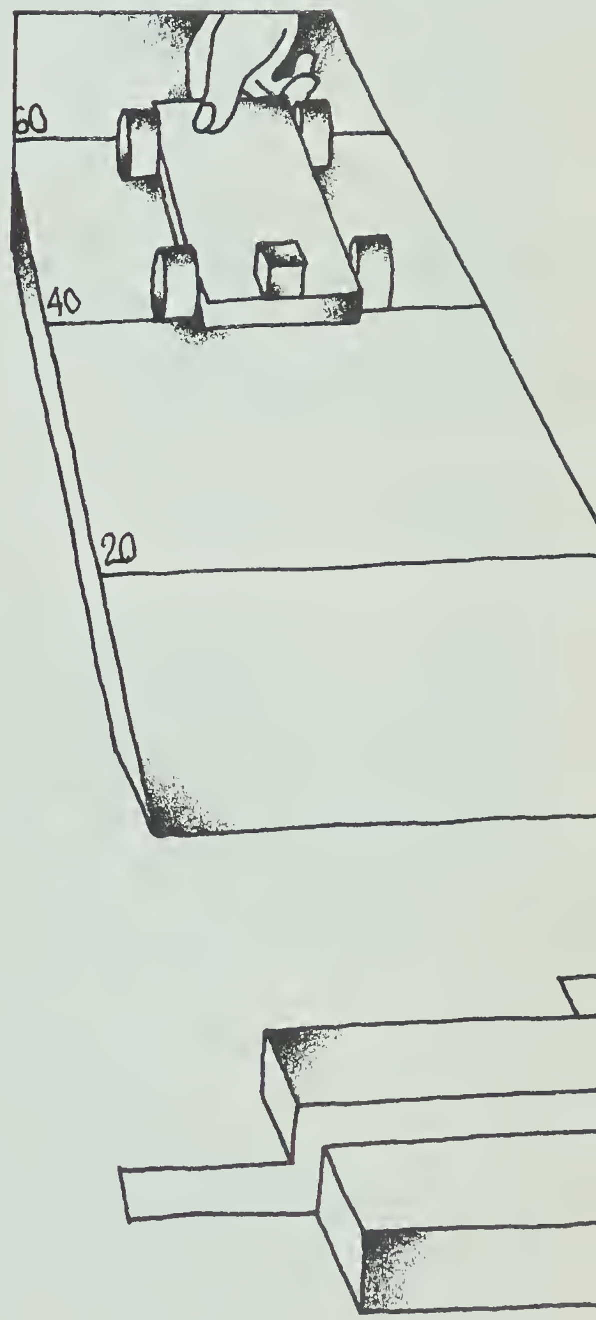
C. Watch what happens to the clay cube. Use chalk to mark where the cube finally stops. Measure the distance from the chalk mark to the impact side of the barrier. Measure to the nearest centimetre.

Repeat Steps B and C three or four times. Record the measurement each time.

You probably will get a different result for each trial. This is because there are variables that change the results: the cart may hit the barrier differently due to small changes in the way the cart rolls on the ramp. Find the average distance for all the trials. Record your results. You may want to use a table like the one in Figure 3–1.

DISTANCE FROM END OF RAMP (IN CENTIMETRES)	AVERAGE DISTANCE CUBE WAS THROWN
20	
40	
60	
80	
100	
120	

Figure 3–1



D. Place the cube on the front of the cart. Release the cart 40 centimetres from the end of the ramp. Do this several times. Each time measure the distance from where the cube lands to the impact side of the barrier. Find the average distance and record it in your table.

Repeat Step D for each distance shown in the table (Figure 3–1). Notice that the last trial you will make is from the 120-cm mark. Don't go above that yet.

✔ 3–1. Graph the data from your table. If you need help with graphing, do *Resource Unit 4*.

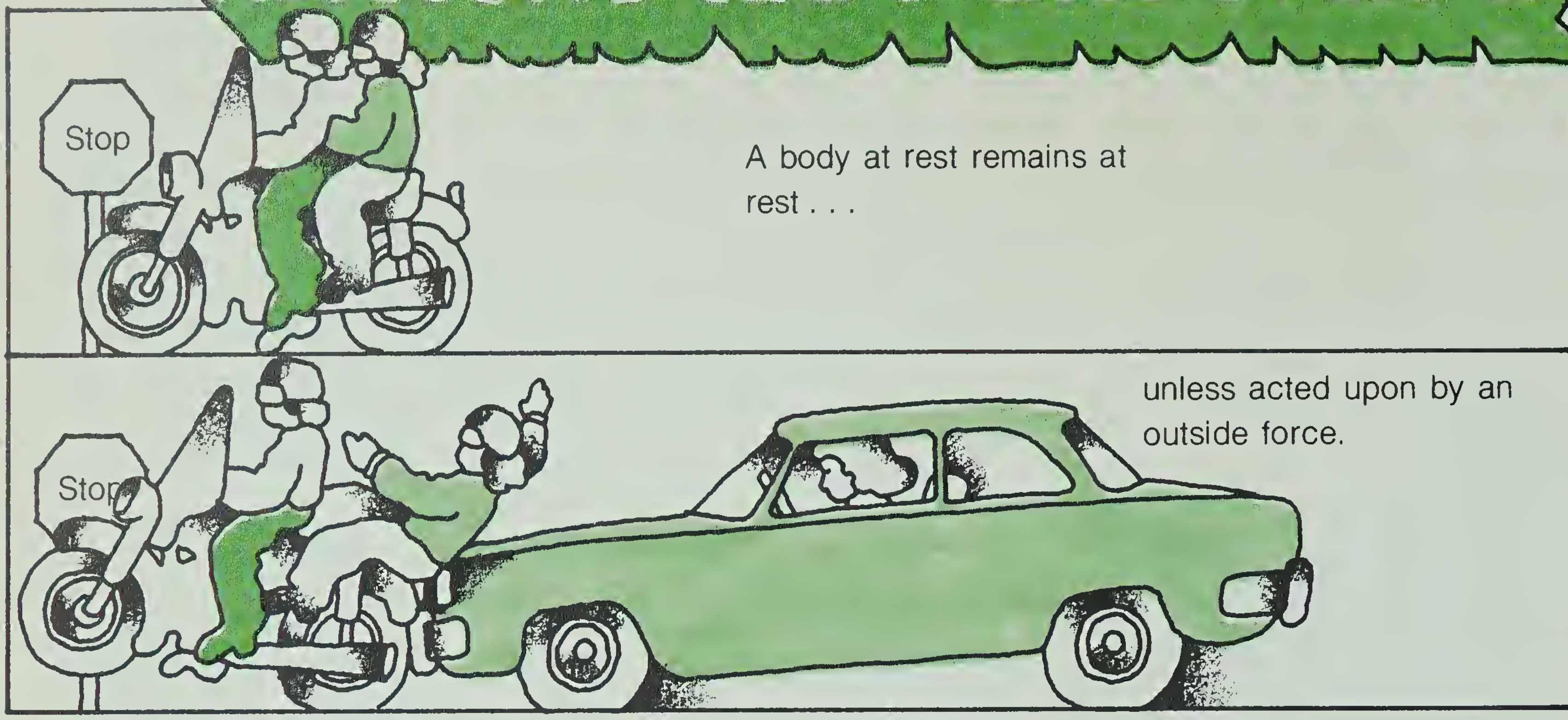
✔ 3–2. Suppose you released the cart and cube from the 140-centimetre mark on the ramp. Use your graph to predict how far the cube would be thrown. (Hint: Extend the graph. If you need help, do *Resource Unit 4*.)

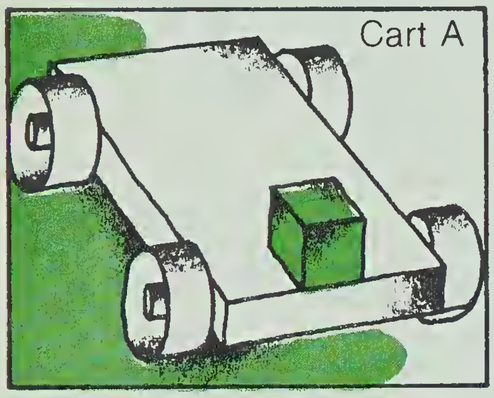
✔ 3–3. Place the cube on the cart. Release the cart 140 centimetres from the end of the ramp. How far is the cube thrown? Was your prediction for Question 3–2 correct?

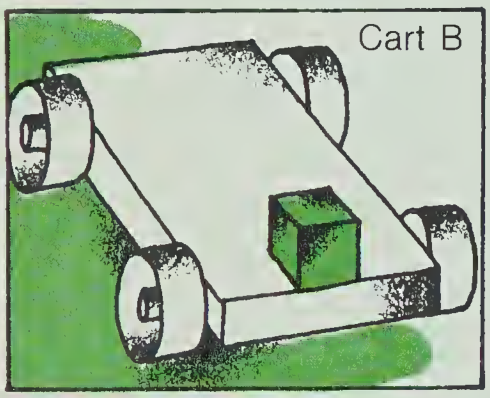
✔ 3–4. When the cube is on the cart it goes in the same direction as the cart. When the cube is thrown from the cart, in what direction does it go?

✔ 3–5. How is the distance that the cube is thrown related to the cart's speed?

NEWTON'S FIRST LAW PART 2





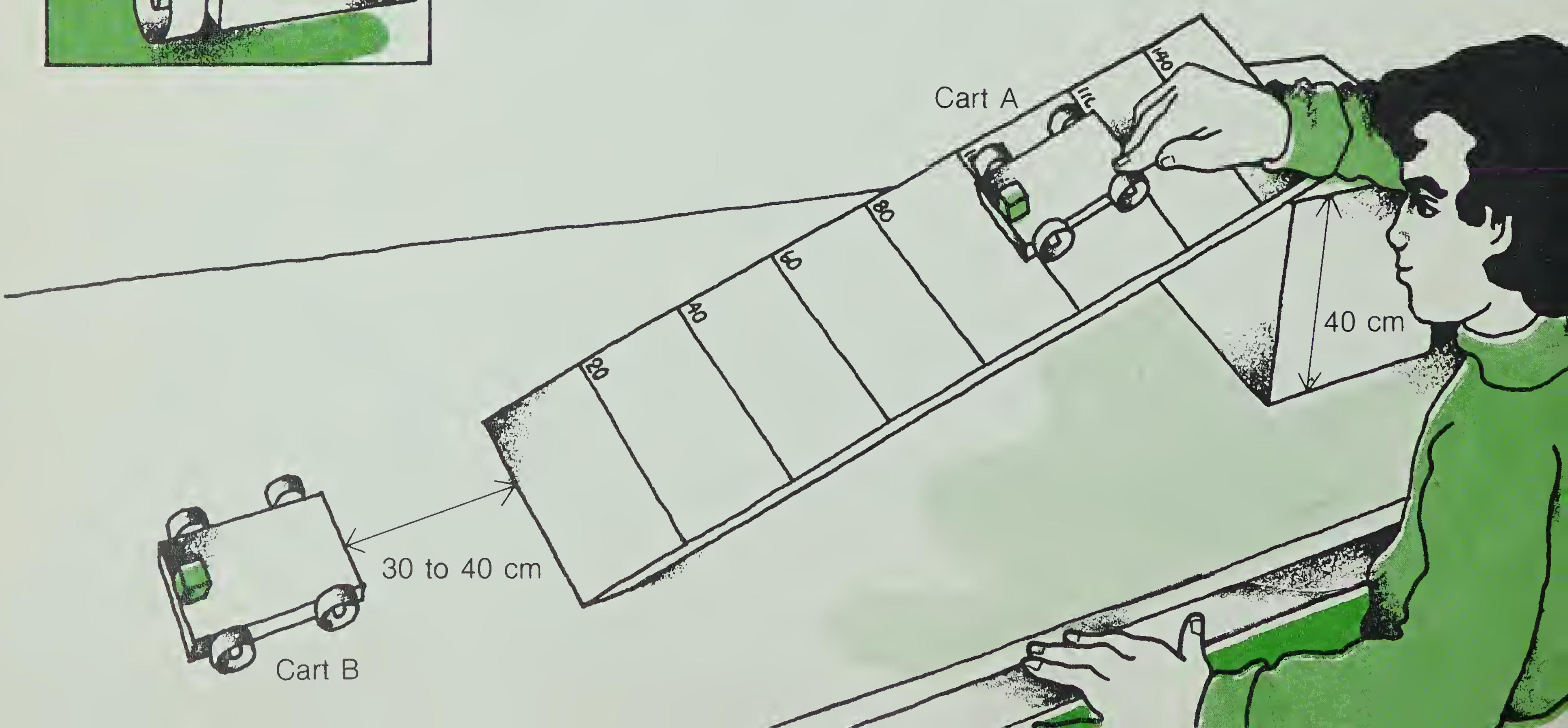


You saw what happens to a loose object when the car suddenly stops. Now you'll see what happens to a loose object when a car at rest gets hit from behind. You'll need these materials:

- ramp, metal or wooden, about 1.5 m long and 30 cm wide
- metric ruler
- cardboard carton or stacked bricks, about 40 cm high
- 2 dynamics carts
- modeling clay to make 2 cubes, each 2 cm on a side

A. Make two clay cubes with sides about 2 cm long. Put a cube on the front of each cart, *Cart A* and *Cart B.*

B. Set up the materials lining up Cart A with the 100-cm mark. Release Cart A. Watch what happens to the cubes.



Repeat Steps A and B three or four times.

✔ 3–6. Did the cube on Cart B move forward, backward, or stay in the same position? Why do you think it did so?

✔ 3–7. Did the cube on Cart A move forward, backward, or stay in the same position? Why do you think it did so?

★ **3–8. A bus lurches forward. Explain why the passengers standing in the aisle are forced toward the back.**

★ **3–9. Shown in Figure 3–2 is a truck with a sturdy wall behind the driver's cab. What is the purpose of this wall?**

★ **3–10. A stopped car is hit from behind by another car. Describe what happens to the people in the**
a. stopped car. b. car that hit the stopped car.

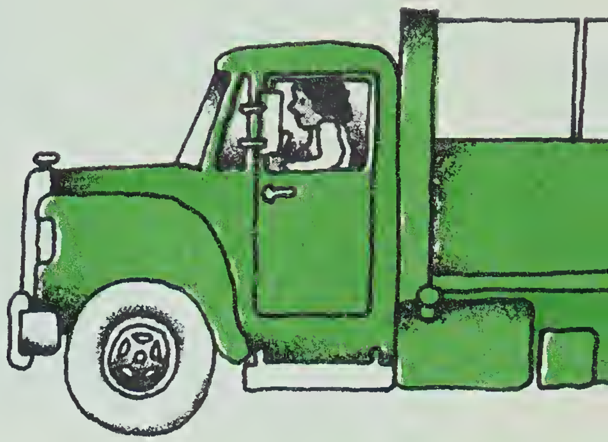
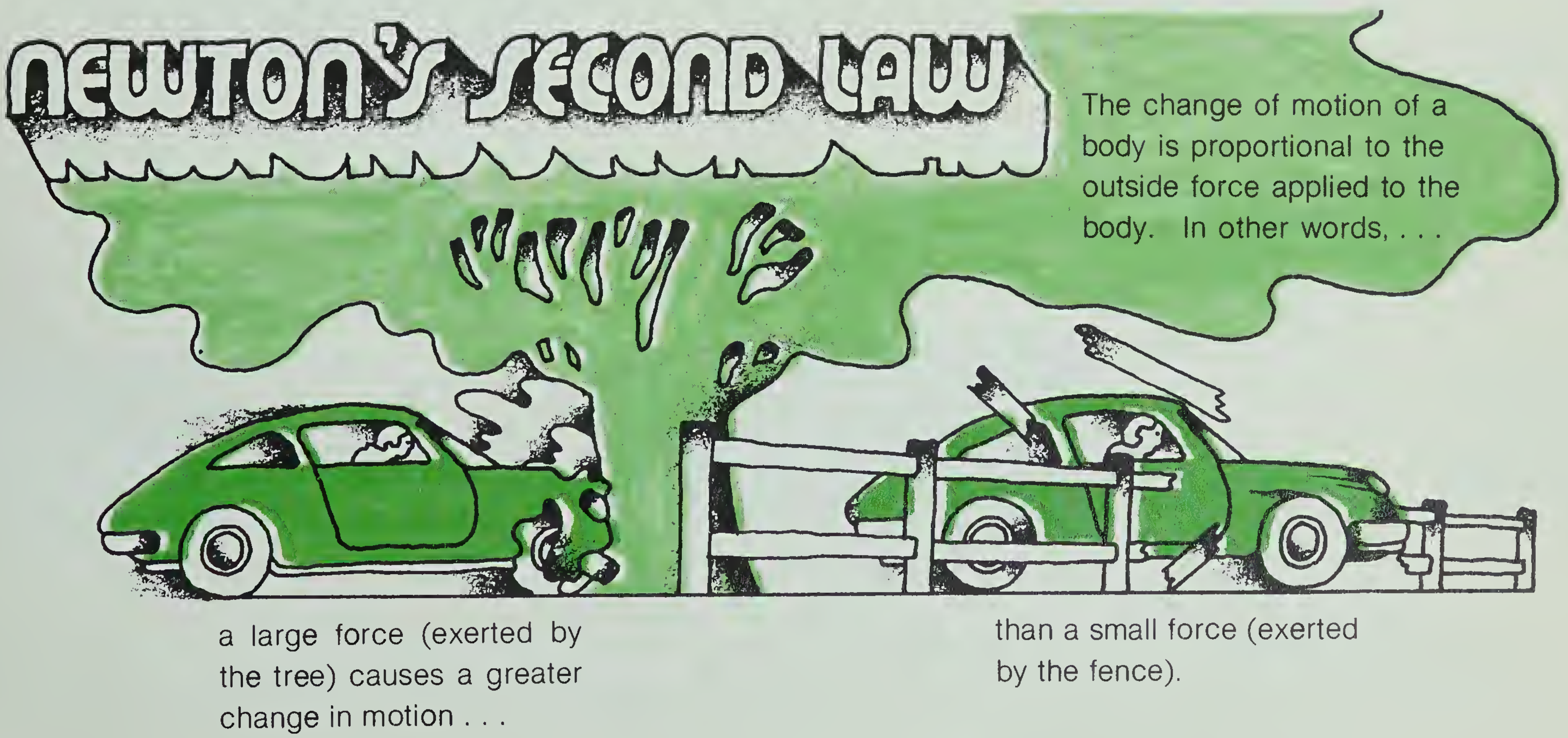


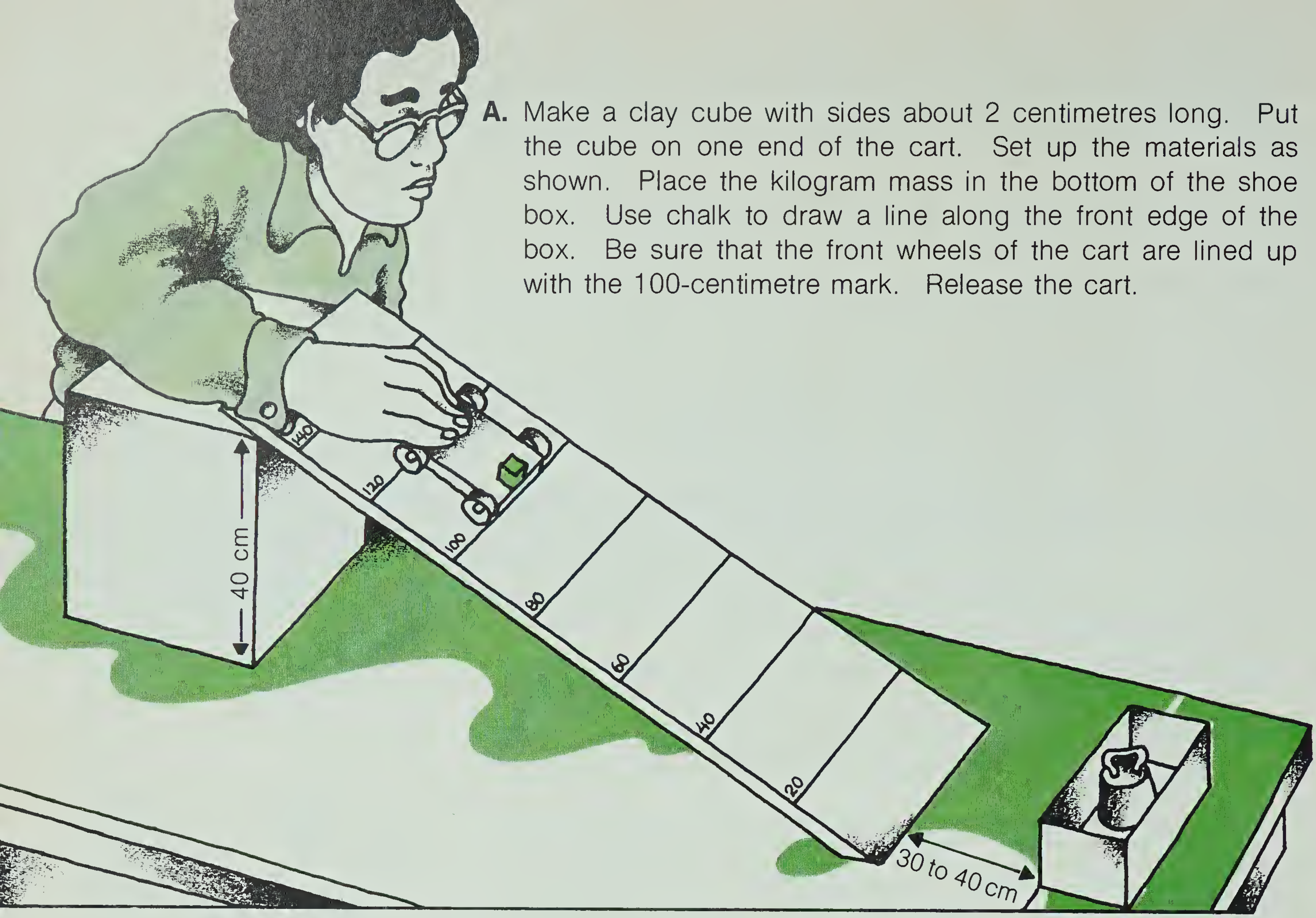
Figure 3–2

Now do another investigation to see what *Newton's second law* is and how it applies to a car crash. You'll need these materials:

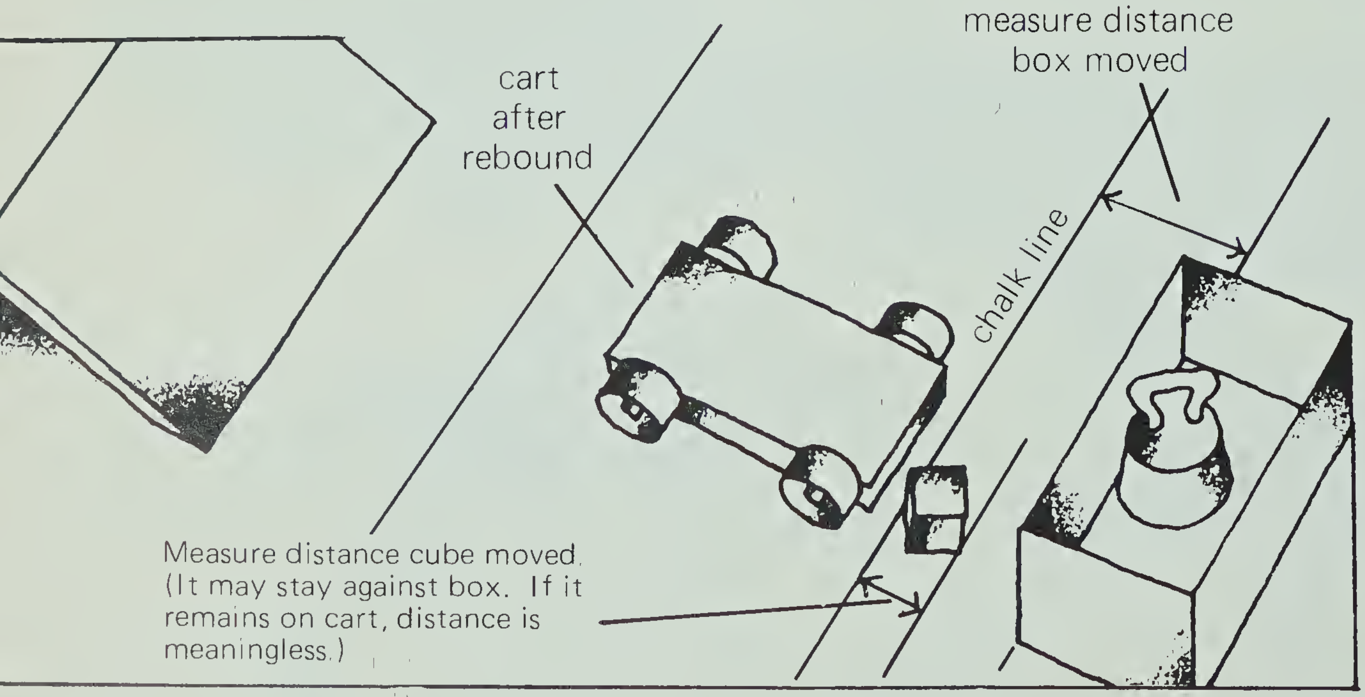
ramp, 1.5 m long, 30 cm wide
metric ruler
cardboard carton or stacked bricks, 40 cm high
dynamics cart
chalk
bottom of shoe box for child's shoes, or similar box
modeling clay to make a cube 2 cm on a side
kg mass
500 g mass



A. Make a clay cube with sides about 2 centimetres long. Put the cube on one end of the cart. Set up the materials as shown. Place the kilogram mass in the bottom of the shoe box. Use chalk to draw a line along the front edge of the box. Be sure that the front wheels of the cart are lined up with the 100-centimetre mark. Release the cart.



B. Watch what happens to the shoe box and the cube (the "passenger") after the collision. Measure the distance that the cube travels. Record the measurement. Do the same for the shoe box. Repeat the procedure three or four times. Then average the distances and record the averages. You may want to use a table like the one in Figure 3–3.



MASS	AVERAGE DISTANCE BOX TRAVELED	AVERAGE DISTANCE CUBE TRAVELED
1 kg		
500 g		
No mass added to box		

Figure 3–3

Repeat Steps A and B using a 500-gram mass in the shoe box. Then repeat Steps A and B using the shoe box without any mass added.

✓ 3–11. How did the mass of the box and its contents affect how far the box moved when the cart hit it?

✓ 3–12. How did the mass of the box and its contents affect how far the clay cube was thrown when the cart hit the box?

★ **3–13. When are serious injuries more likely to happen—when a car crashes into a large tree or into a wooden fence?**

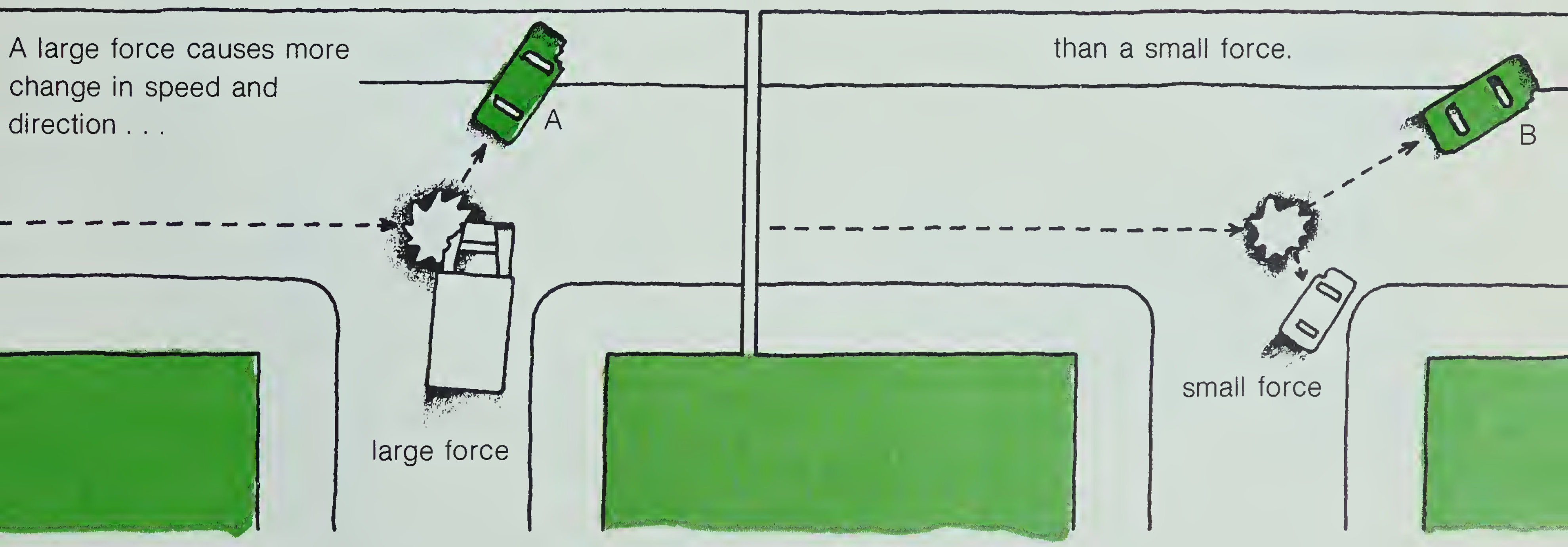


Figure 3–4

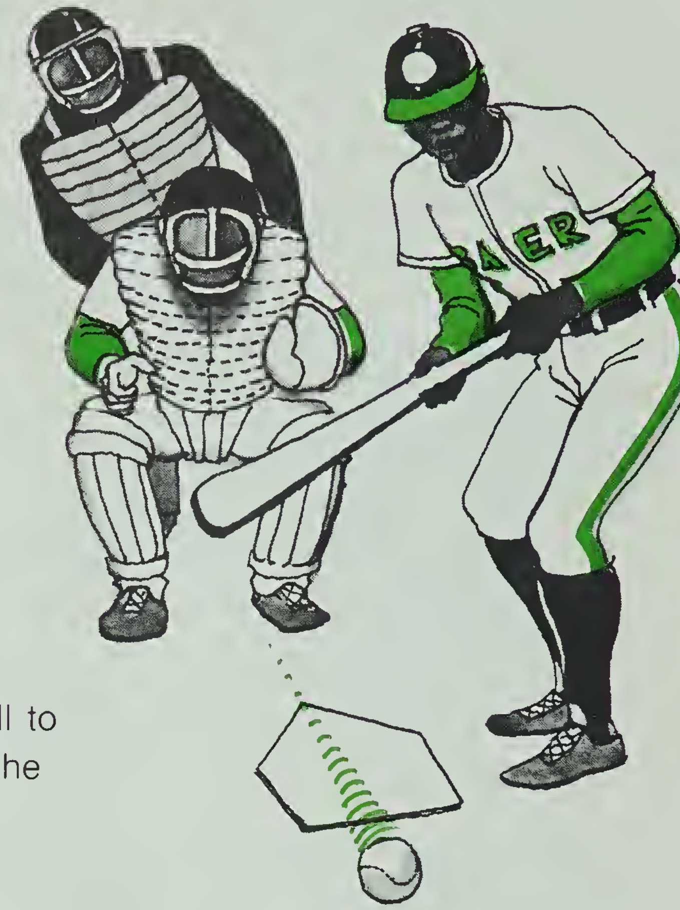
✓ 3–14. Look at Figure 3–4. Why did Car A slow down more and have a greater change in direction than Car B?

Two of Newton's laws are:

1. A body in motion remains in motion, and a body at rest remains at rest unless acted upon by an outside force.
2. When a force acts on an object, the amount of motion change, either in speed or direction, depends on the size of the force and the amount of time the force is applied.

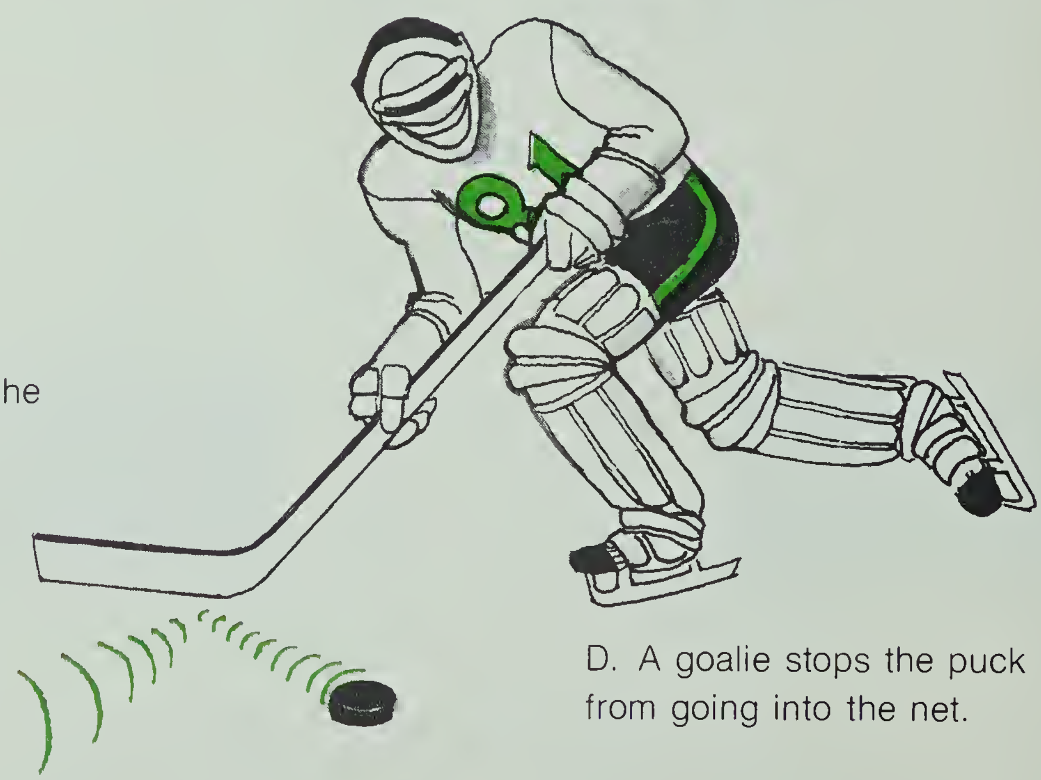
✔ 3–15. Describe how Newton's laws apply in these situations.

A. A billiard ball rolls toward and collides with an unmoving ball.



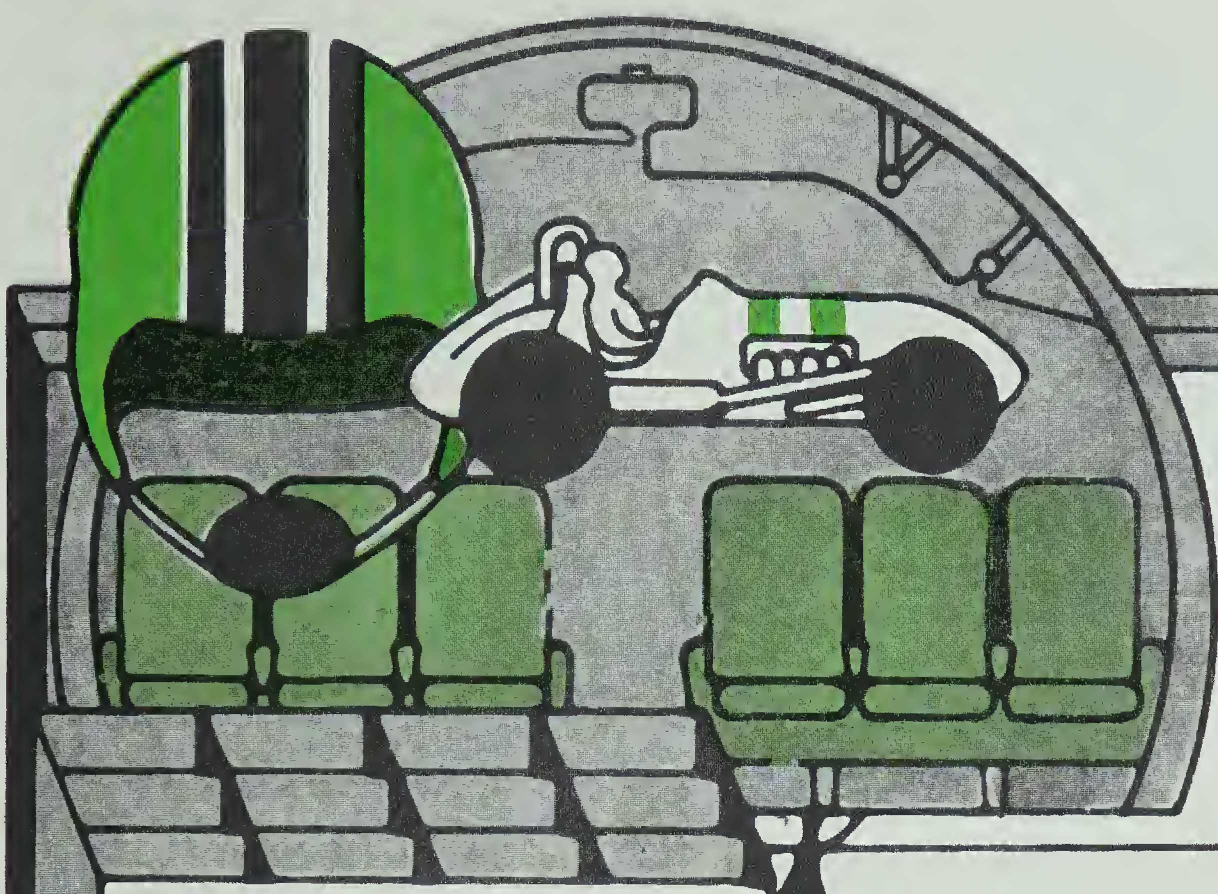
B. A batter bunts a ball to the ground in front of the plate.

C. A golfer hits a ball off the tee.



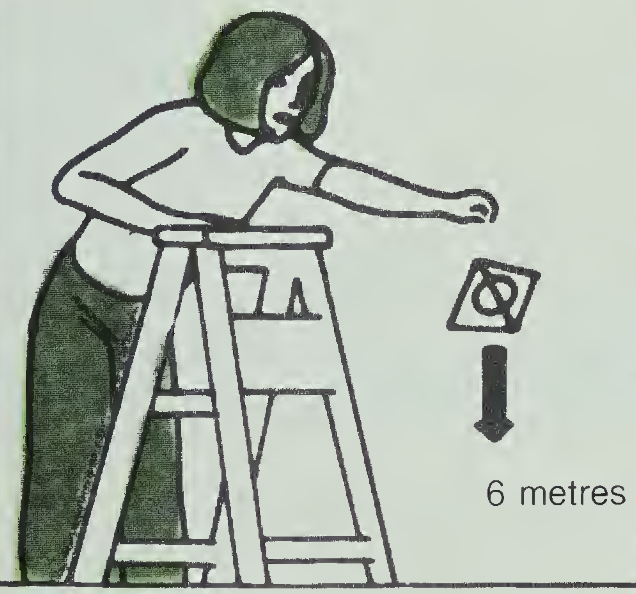
D. A goalie stops the puck from going into the net.

Packaging An Egg



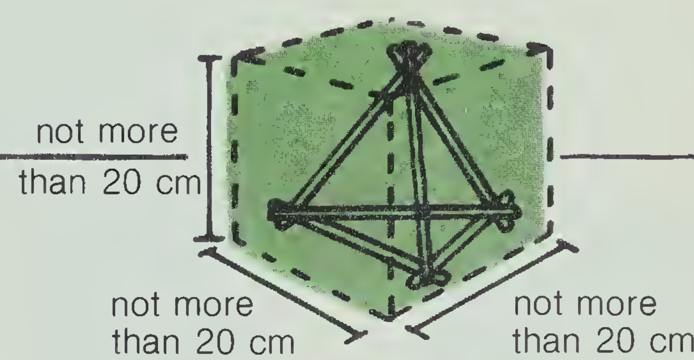
The principles of safe packaging do not change, no matter what you are packaging.

In this activity you'll use safe-packaging principles to package an egg. The egg must survive a 6-metre drop without cracking.



RULES FOR PACKAGING

You may use any or every car safety feature described in this minicourse. The only restriction is that your package may not measure more than 20 centimetres in length, width, or depth.



Write a report on how you packaged the egg. Use a well-labeled diagram or photograph to show how your package was made. Write a brief statement on what happened when you tried it out. Then show off your package and brag about it.

Protecting Passengers

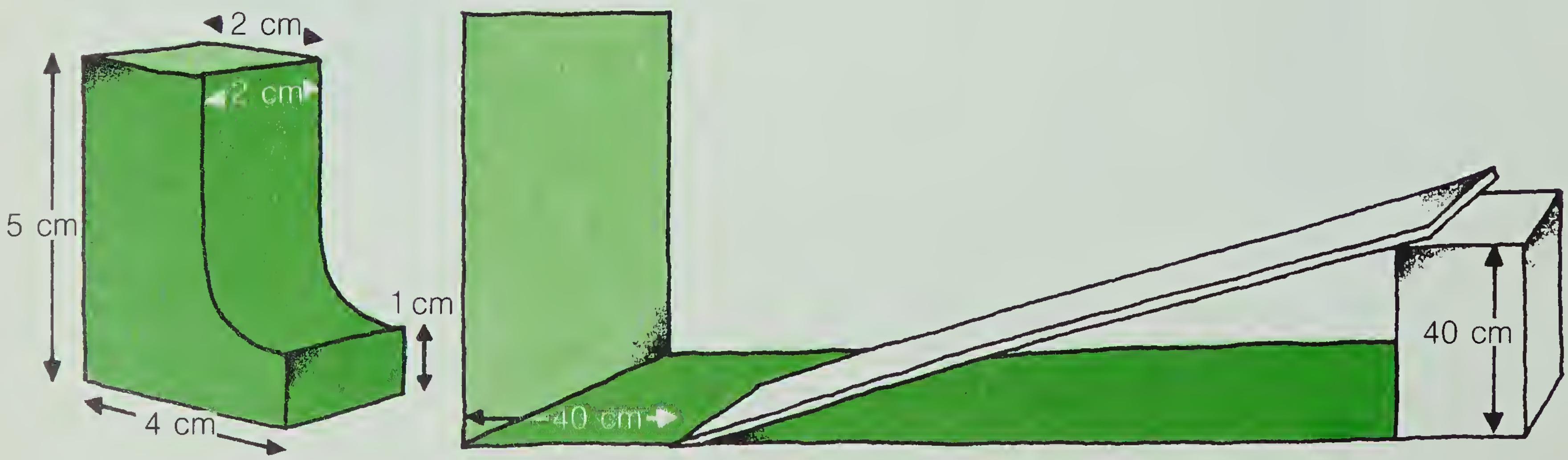
Seat belts and shoulder harnesses hold passengers in place. Ideally, in a crash, a passenger wearing a seat belt and harness should not be thrown from a car. And that person's body should be restrained from hitting the interior of the car. But are seat belts and harnesses really that good?

In the following investigation you'll make and test a padded dashboard, a safety belt system, and an air bag system. You'll need these materials:

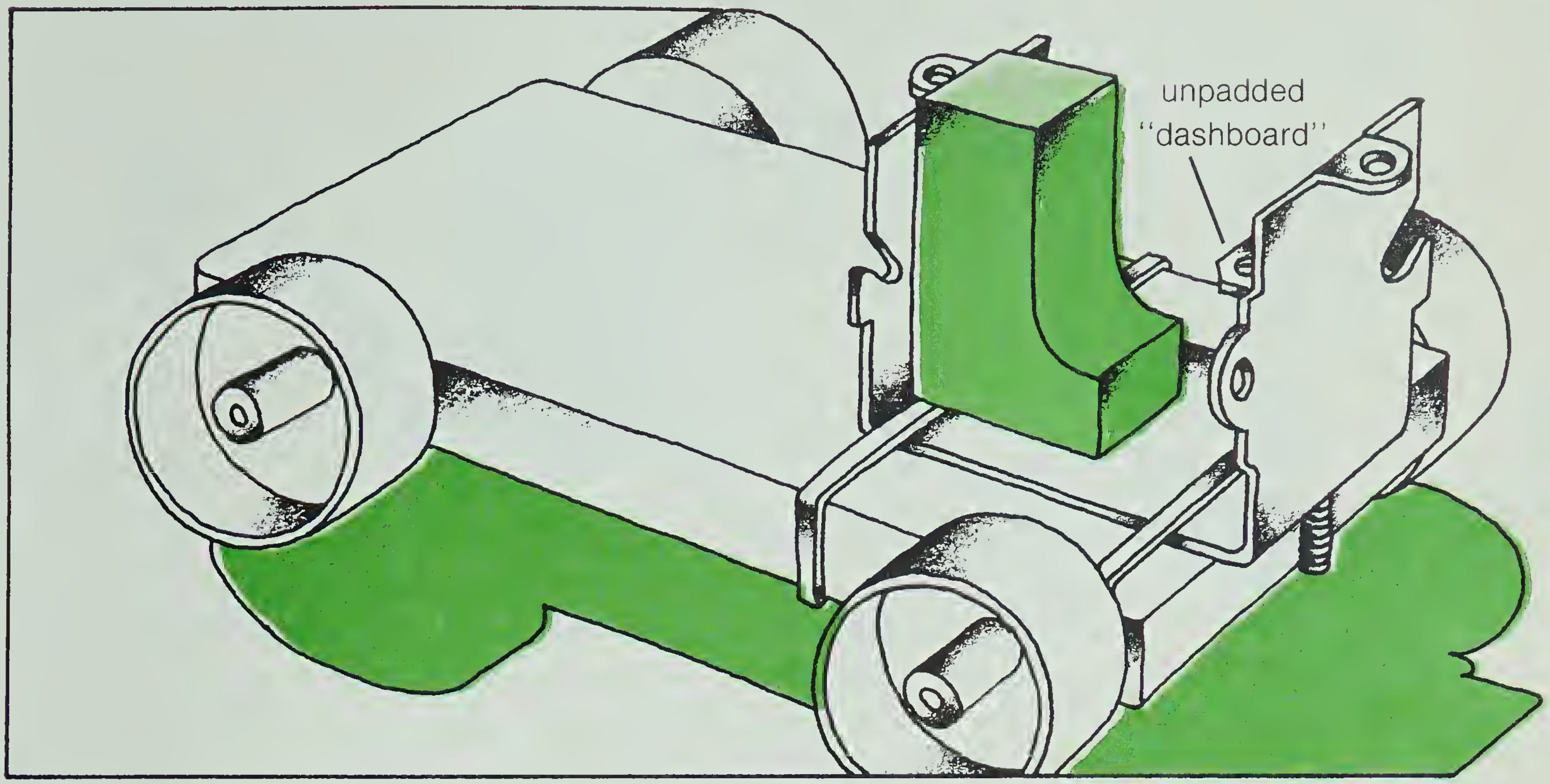
ramp, metal or wooden, about 1.5 m long and 30 cm wide
cardboard carton or stacked bricks, about 40 cm high
cube of modeling clay, 3.5 cm on a side
metric ruler
car assembly
dynamics cart
strong rubber bands
chalk
rubber tubing, 4 cm long, about 1 cm in diameter
thread
2 shoelaces, or cord of similar diameter
medium-weight rubber bands
scissors
small rubber balloon
masking tape

A. Set up the materials as shown in the drawing.

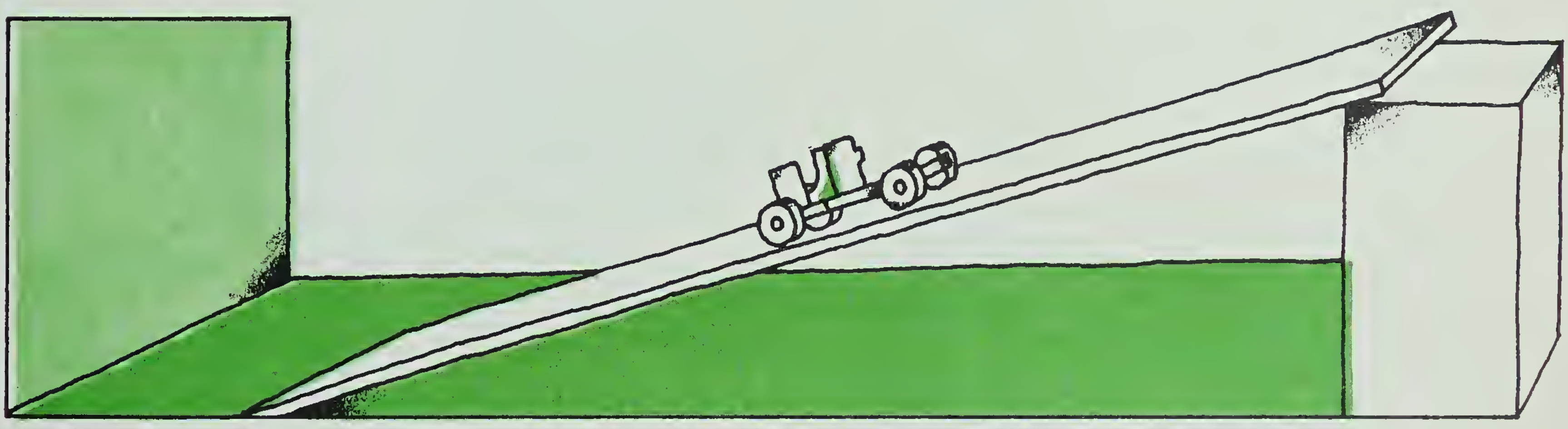
B. Use soft clay to model a "passenger" as shown. Be sure that the surface of the passenger is smooth. If the clay is hard, soften it by working it in your hands.



C. Put the car assembly on the cart. It should overhang the end of the cart by about 1 centimetre. Use strong rubber bands to hold the assembly in place. Place the passenger inside.



D. Place the cart about halfway up the ramp. Use chalk to mark the starting position. (You'll be using this position again.) Release the cart.

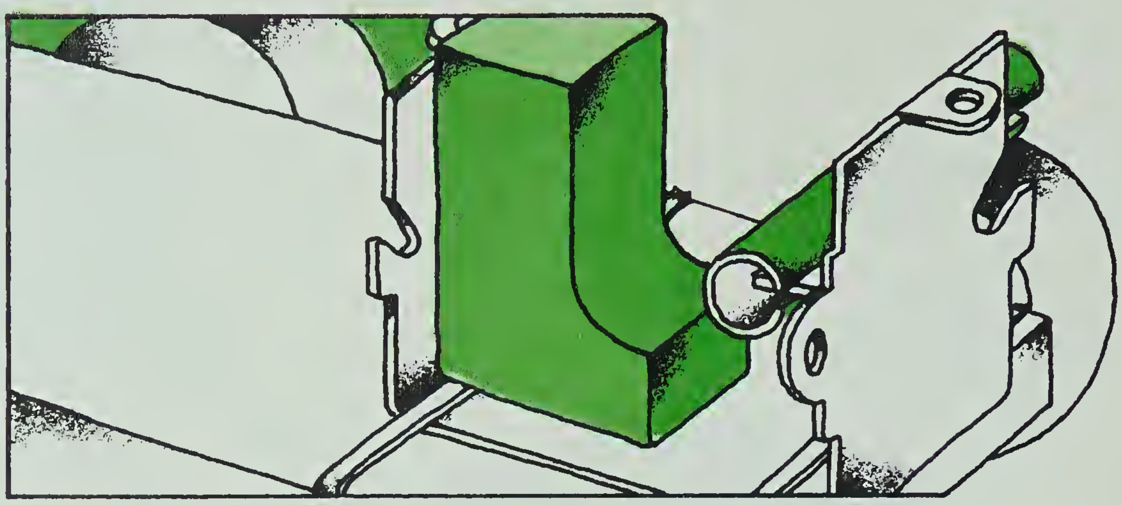


✔ 5–1. What happened to the passenger when the cart hit the wall?

✔ 5–2. Examine the passenger. Describe any damage that was done.

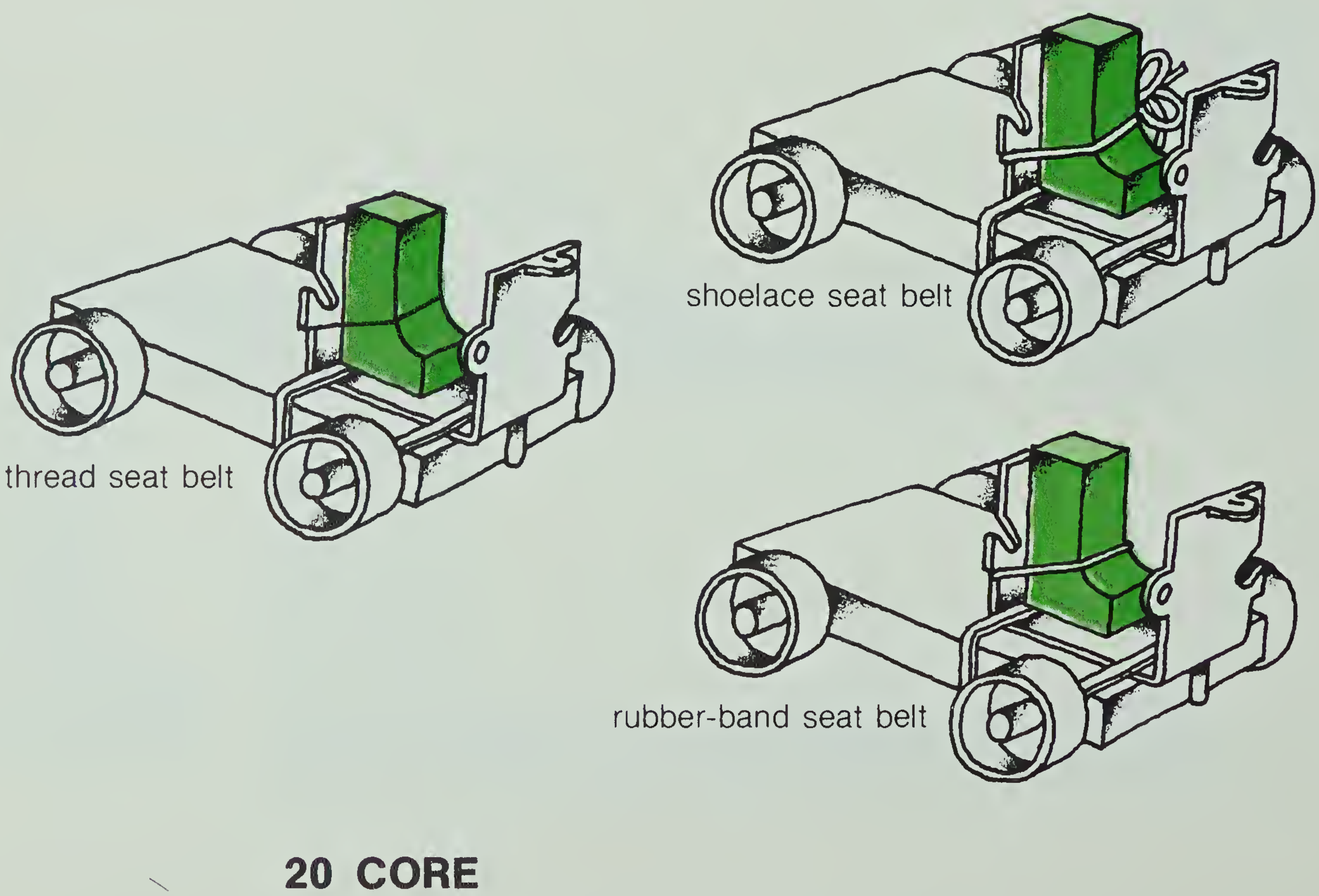
★ **5–3. In a car crash, injuries occur when a person slams into the dashboard. How might these injuries be lessened?**

E. Slit the rubber tubing as shown in the drawing. Place the tubing over the dashboard. You've just made a "padded dash." Remodel the passenger and place it in the cart. Put the cart at the starting mark on the ramp and release it. Observe what happens to the passenger when the cart hits the wall.



★ **5–4. What is the major advantage of a padded dash over one not padded?**

F. Remodel the clay passenger. Make one of the three seat belts shown in the drawing. Place the cart on the ramp at the starting mark. Release the cart and observe what happens to the passenger. Repeat this procedure for each of the three types of seat belts.



✔ 5-5. Which belt (or belts) kept the passenger from striking the dashboard? Which did not?

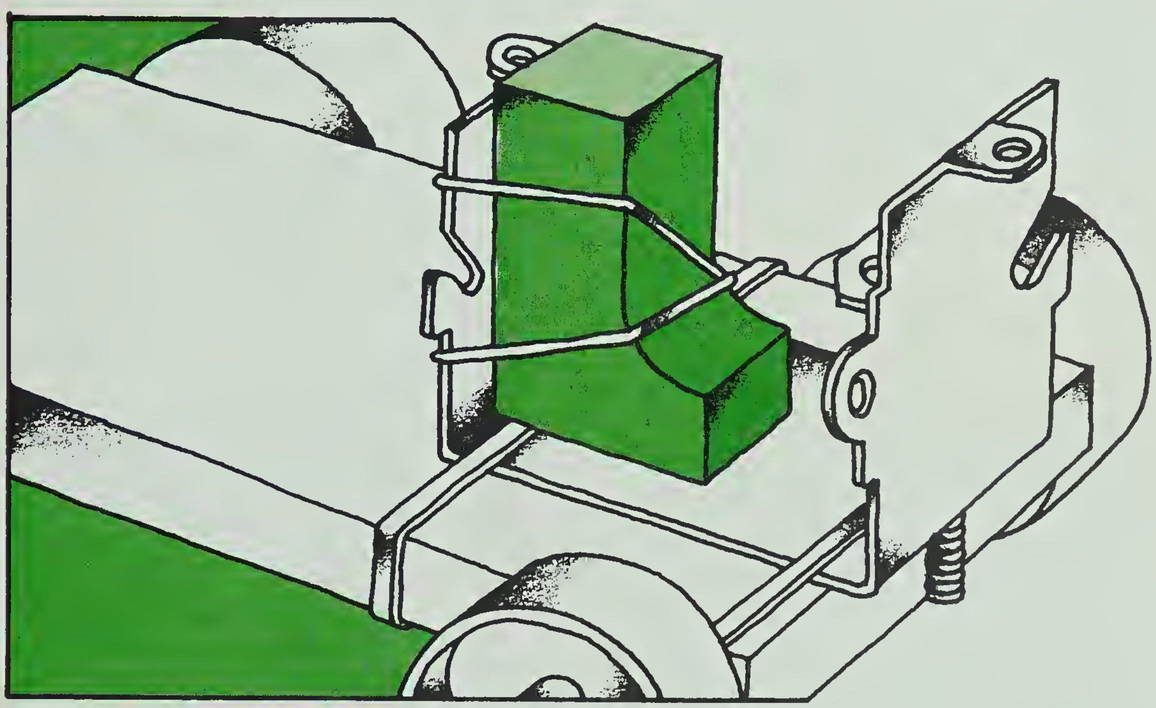
✔ 5-6. Which belt was used when the passenger suffered the least injury?

✔ 5-7. Which belt was used when the passenger suffered the most injury?

★ **5-8. Describe the belt that gives the best protection to a passenger.**

Many people say seat belts are bad because they "trap you in the car." These people think that it's better to be thrown out of the car and clear of the crash. But crash records don't agree.

G. Remodel your passenger. Choose the seat belt from Step F that worked the best. Make a shoulder harness from the same material as the seat belt. Then put the seat belt and shoulder harness around the passenger. Place the cart at the starting mark on the ramp. Release the cart.



✔ 5-9. Examine the passenger. Describe any damage that was done.

★ **5-10. What is the major advantage of a seat belt-shoulder harness system over a seat belt system?**

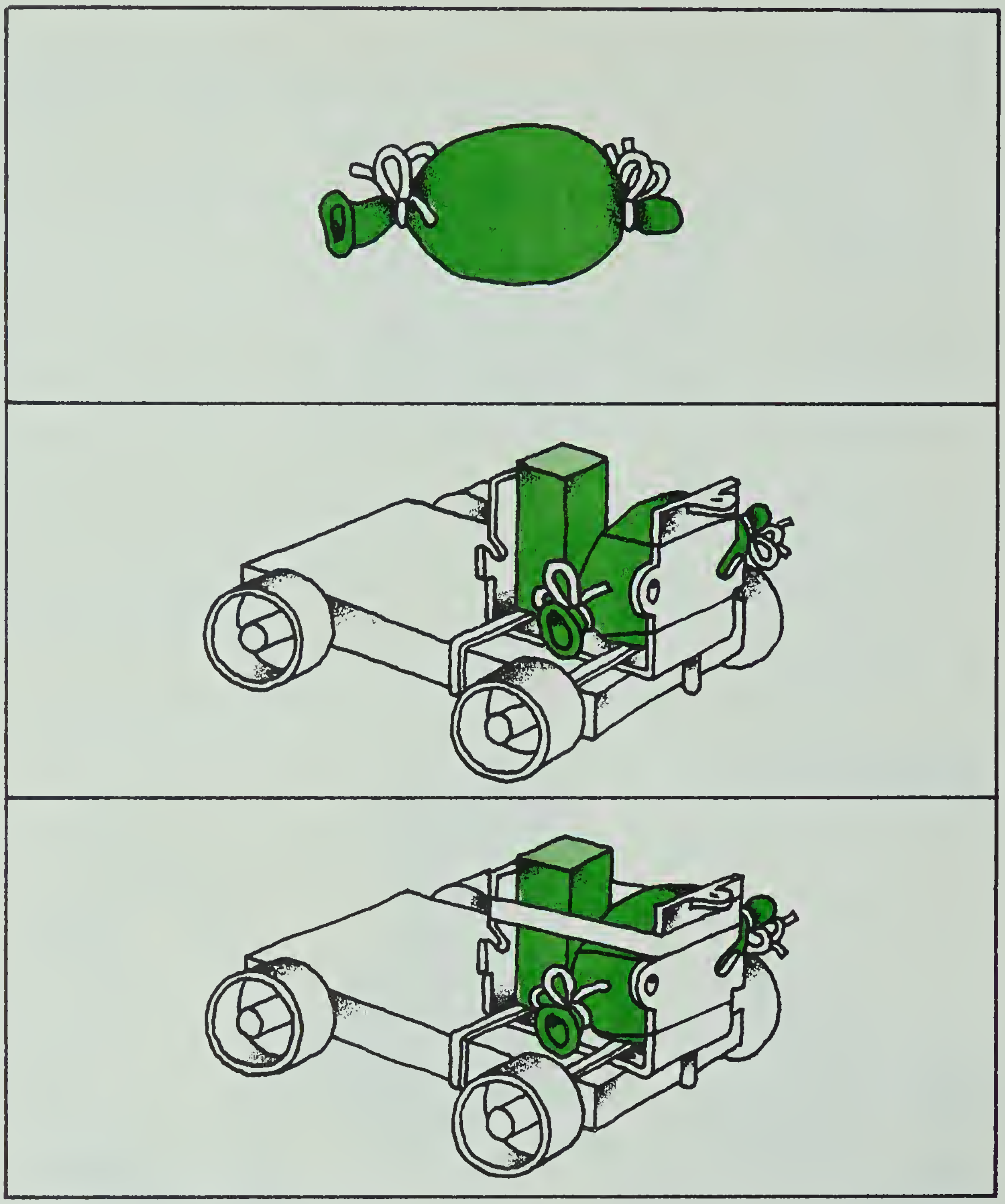
You've seen how a padded dashboard and a seat belt-harness system protect a passenger. Now you'll see what an air bag system does.

H. Remodel the clay passenger and prepare the balloon as shown. Then place the cart at the starting mark on the ramp. Release the cart.

1. Fill the balloon with just enough air to support its walls. Tie the nozzle end shut with thread. Then tie the opposite end shut. This prevents the air from being pushed into either end of the balloon.

2. Tie the balloon to the car assembly so that it covers the dashboard. Press your finger into the balloon. The balloon should resist so that you do not feel the dashboard. (You may have to put more air in the balloon.)

3. Put a strip of tape around the sides of the assembly to keep the passenger inside.



✔ 5-11. Examine the passenger. Describe any damage that was done.

✔ 5-12. Describe how you could improve the passenger's chance of being uninjured. Try out your idea!

★ **5-13. How do air bag systems protect passengers from injuries during accidents?**

★ **5-14. What is the best possible system for protecting passengers inside a car?**

Restraining Systems—Seat Belts

Dummies (life-size dolls) are used for studying results of safety tests. The photographs in Figures 6–1, 6–2, and 6–3 were taken at a General Motors proving (testing) ground.

The car in Figure 6–1 had seat belts but they weren't used. A "child" dummy had been kneeling in the back seat, looking out the back window. This dummy ended up against the front windshield. A real child could have suffered a broken back.

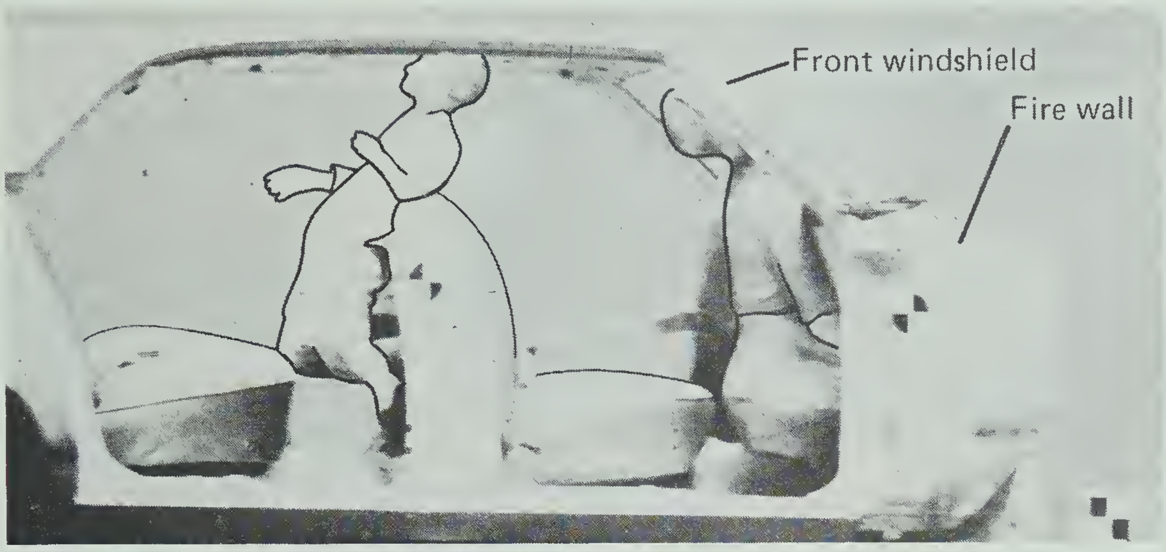


Figure 6–1

Notice that a seat belt was used for the safety test shown in Figure 6–2.

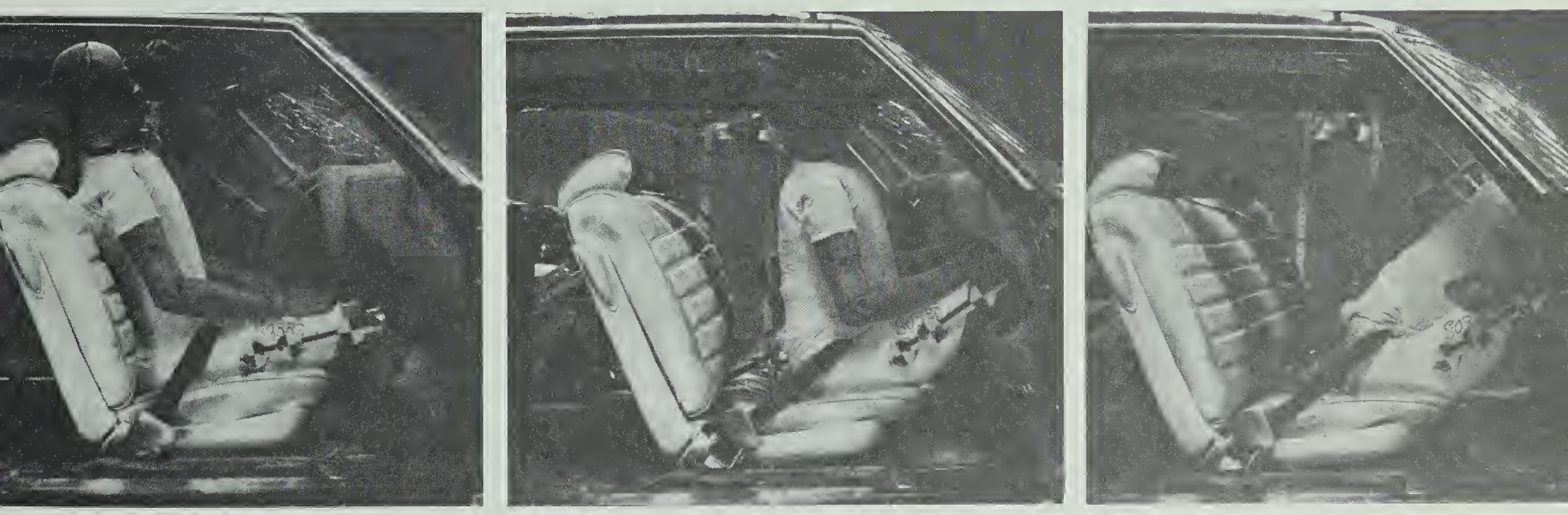


Figure 6–2

In Figure 6–3 the dummy is wearing a seat belt and shoulder harness. On the side of the dummy's head is a checked strip of tape. Notice the head stops just short of the windshield (Frame D). Then the dummy is pulled back (Frame E).

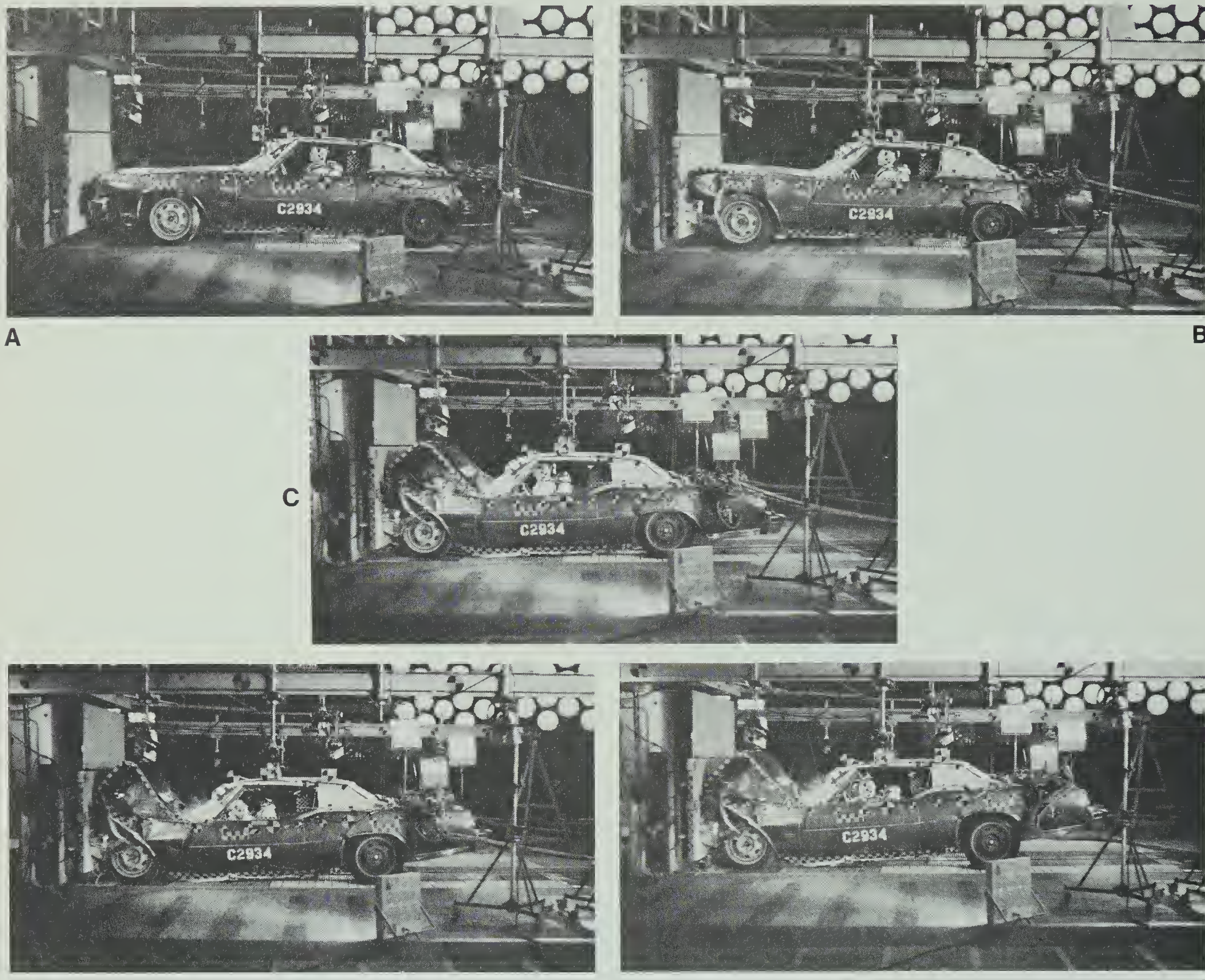


Figure 6–3

✓ 6–1. Look at the dummy in the front seat. Did the dummy's knees hit the fire wall in Figure 6–1? In Figure 6–2? In Figure 6–3?

✓ 6–2. Did the dummy's head hit the dashboard or windshield in Figure 6–1? In Figure 6–2? In Figure 6–3?

✓ 6–3. Did the dummy's head go through the windshield in Figure 6–1? In Figure 6–2? In Figure 6–3?

✓ 6–4. Based on your answers to the questions, do you think seat belts reduce injuries in car crashes?

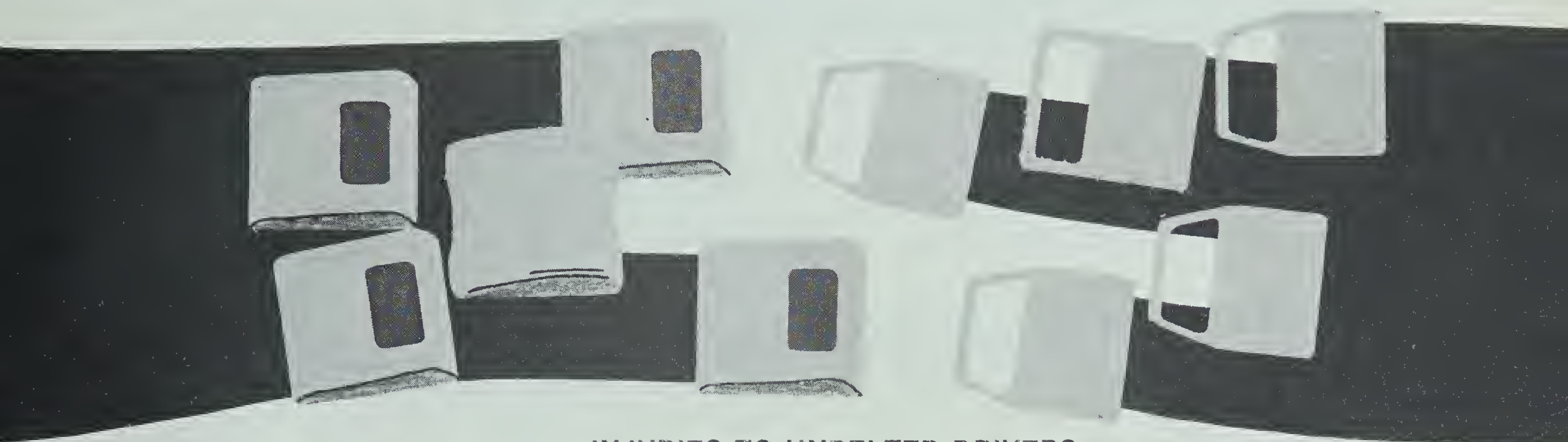
Just how well do seat belts reduce injuries? In one survey, Volvo investigated thousands of accidents in Sweden. Part of the survey is shown in Figures 6–4 and 6–5. Notice that the drivers were "unbelted" (Figure 6–4) and "belted" (Figure 6–5). The percentages were approximated for the information shown.

The following questions are about unbelted drivers. You'll need to refer to Figure 6–4 when answering these questions.

✔ 6–5. Were any drivers killed when the speed was less than 20 kilometres (12 miles) an hour?

✔ 6–6. At what speed did the highest percentage of accidents occur? How many people were seriously injured or killed in those accidents?

✔ 6–7. Based on the data, at what speeds should seat belts be fastened so as to prevent serious injury or death?



INJURIES TO UNBELTED DRIVERS

TYPE OF INJURY	**SPEED** (kilometres per hour)								
	Not moving	Less than 20	20–40	About 50	About 60	70–90	About 100	More than 100	Total
Fatal injuries (deaths)	0	2	5	2	1	13	5	9	37
Serious injuries	7	12	50	44	45	74	26	5	263
Light injuries	35	65	245	126	115	189	40	20	835
Non-injured	2302	4865	7643	2446	1427	1462	175	51	20,371
Total	2344	4944	7943	2618	1588	1738	246	85	21,506
Percentage of total accidents	11	23	37	12	7	8	1	1	100

Figure 6–4

INJURIES TO BELTED DRIVERS

TYPE OF INJURY	SPEED (kilometres per hour)								
	Not moving	Less than 20	20–40	About 50	About 60	70–90	About 100	More than 100	Total
Fatal injuries (deaths)	0	0	0	0	0	0	3	3	6
Serious injuries	9	3	19	25	16	60	16	13	161
Light injuries	47	41	106	106	72	125	38	13	548
Non-injured	2266	4229	6786	2661	2053	2398	297	100	20,790
Total	2322	4273	6911	2792	2141	2583	354	129	21,505
Percentage of total accidents	11	20	32	13	9	12	2	1	100

Figure 6–5

Questions 6–8, 6–9, and 6–10 are about belted drivers. Refer to Figure 6–5 when answering these questions.

✓ 6–8. What was the slowest speed at which a driver was killed?

★ **6–9. At what speed did the highest percentage of accidents occur? How many people were seriously injured or killed in those accidents?**

★ **6–10. Consider the speed you chose for Question 6–9. How do seat belts improve the chance of not being seriously injured or killed at that speed?**

★ **6–11. Some drivers wear seat belts only when driving at high speeds. What do you see in the survey (Figures 6–4 and 6–5) that suggests seat belts should be worn at all times?**

Look at the graph in Figure 6–6. The bars make it easy to compare the injuries of 10,000 unbelted drivers with the injuries of 10,000 belted drivers. The colored bars are for the belted drivers; the other bars are for the unbelted drivers. Minor injuries to arms and legs are not included.

INJURIES TO UNBELTED AND BELTED DRIVERS

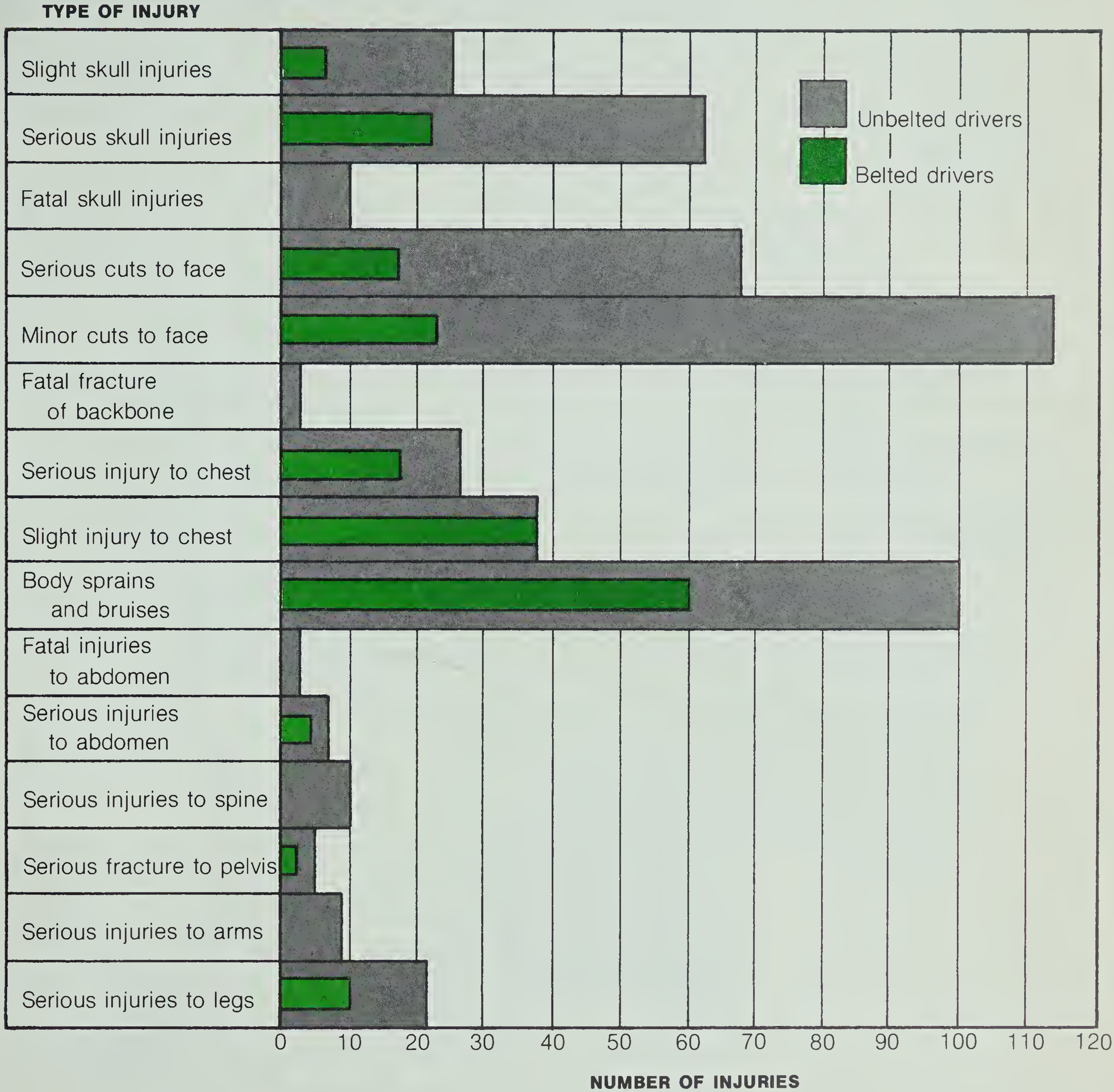


Figure 6–6

Refer to Figure 6–6 when answering these questions. If you have trouble reading the graph, refer to *Resource Unit 2.*

★ **6–12. Which serious or fatal injuries were reduced in number by the use of seat belts?**

★ **6–13. Which injuries killed unbelted drivers but did not kill belted drivers? Describe how these injuries may have happened.**

✓ 6–14. Which injury happened as much to belted drivers as to unbelted drivers? Suggest some safety features that would prevent this injury from happening.

As you can see, seat belts are very effective. In fact, the NHTSA (National Highway Traffic Safety Administration) strongly supports the use of seat belts. NHTSA feels that if everyone wore a seat belt, deaths would decline by about 40 percent and injuries by about 28 percent.

Restraining Systems—Air Bags

Buzzers and flashing lights are made to annoy you. They force you to buckle up so that you can have some peace and quiet.

But a light can be ignored; a bag of groceries or a pet can set off a buzzer.

All modern cars have seat belts. A seat belt combined with a shoulder harness is a cheap and effective restraining system. But many people just won't buckle up. And a seat belt hanging on its hook doesn't do much good.

There are other restraining systems besides seat belts. One is the air bag system. It was first introduced in test cars in 1973. The air bag system is a passive restraint; the motorist does not have to do anything. That's why many people think air bags are less troublesome than belts. The parts of an air bag system are shown in Figure 7–1. These parts cannot be seen when the system is actually installed in a car.

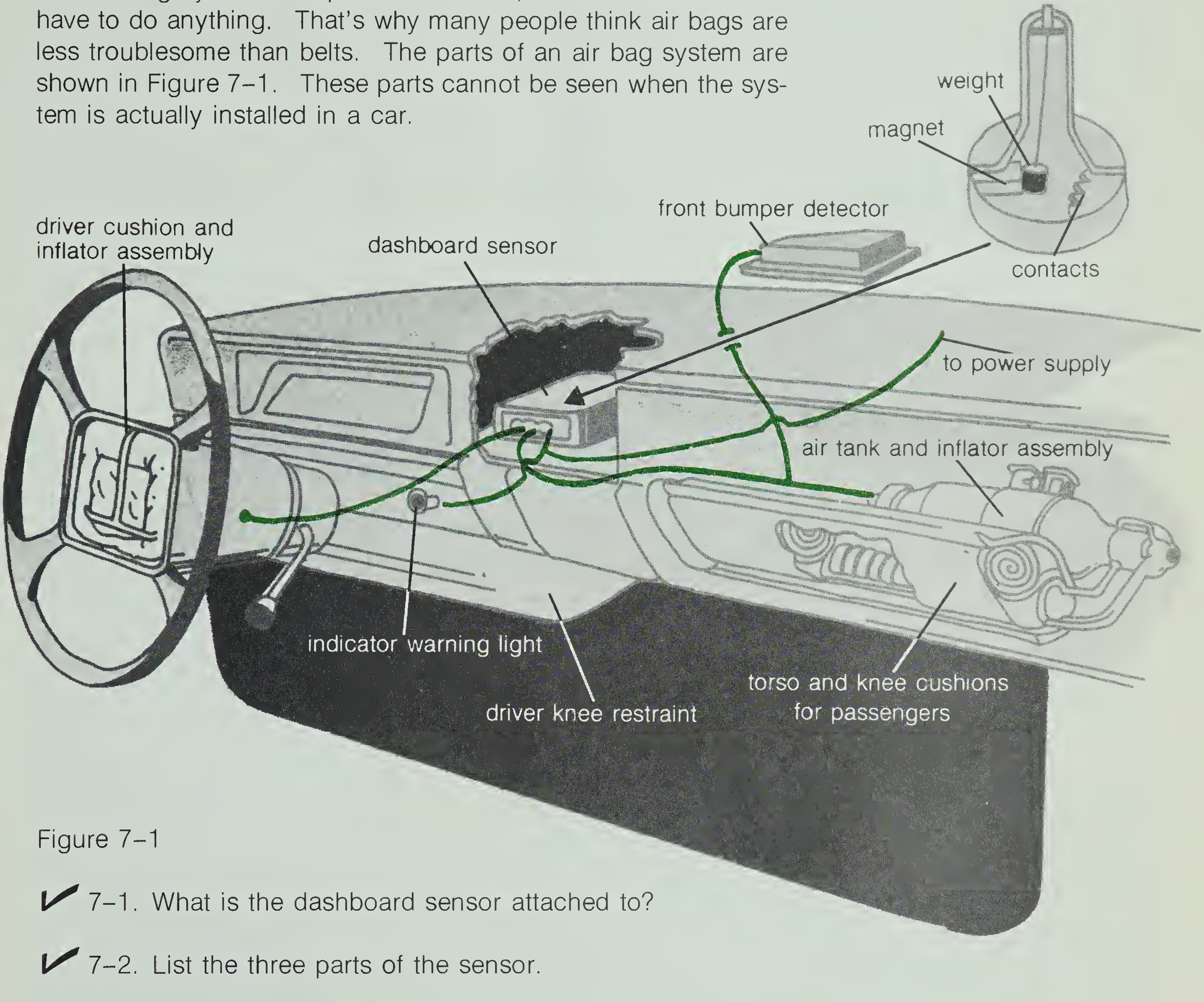


Figure 7–1

✔ 7–1. What is the dashboard sensor attached to?

✔ 7–2. List the three parts of the sensor.

When a car is going about 19 kilometres (12 miles) an hour or more, and crashes, the air bag system is set off. The bags fill with air in a fraction of a second. They stop the motorist from slamming into the steering wheel, dashboard, or windshield. Then the bags deflate so that the motorist is not trapped inside the car. The pictures in Figure 7–2 show what happens.

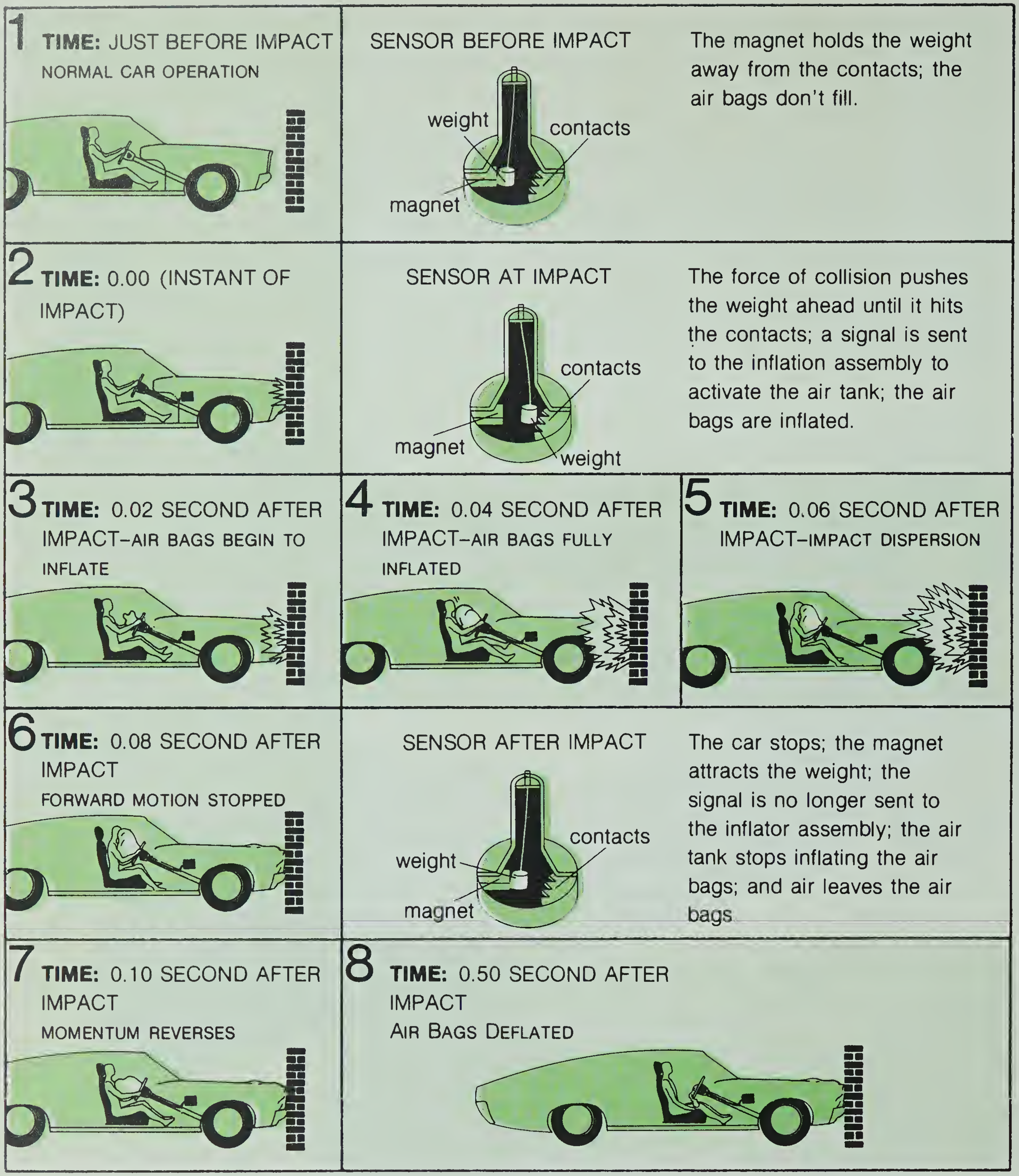


Figure 7–2

✔ 7–3. How long after impact does it take for an air bag to become fully inflated?

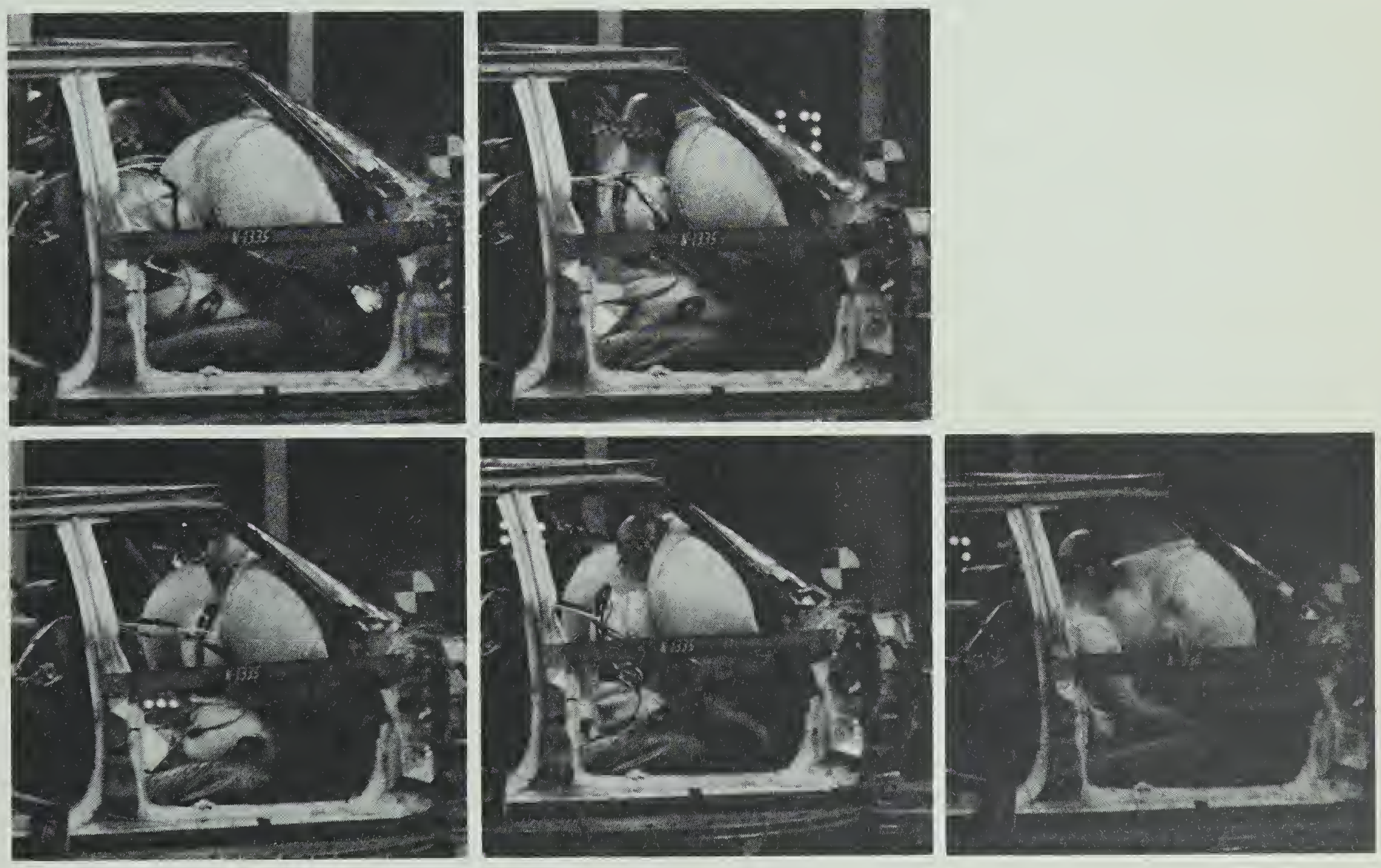
In a head-on collision, the air bag is probably better than a seat belt. The bag is in contact with a large portion of a person's body. This means that the force of impact is spread over much of the body. But air bags do not stop a motorist from being thrown out of the car when it rolls over or is in a side collision. And air bags do not inflate in low-speed crashes, rear-end impacts, or during sharp turns that are made to avoid objects.

The photographs in Figure 7–3 show an air bag system in action. The pictures were taken during a test collision. Frame 1 was taken about 0.04 second after impact. The bag is completely inflated when the dummy just begins to leave its seat.

In Frame 2, the bag is cushioning the dummy's forward movement. Notice the large area of the dummy's body that is in contact with the bag.

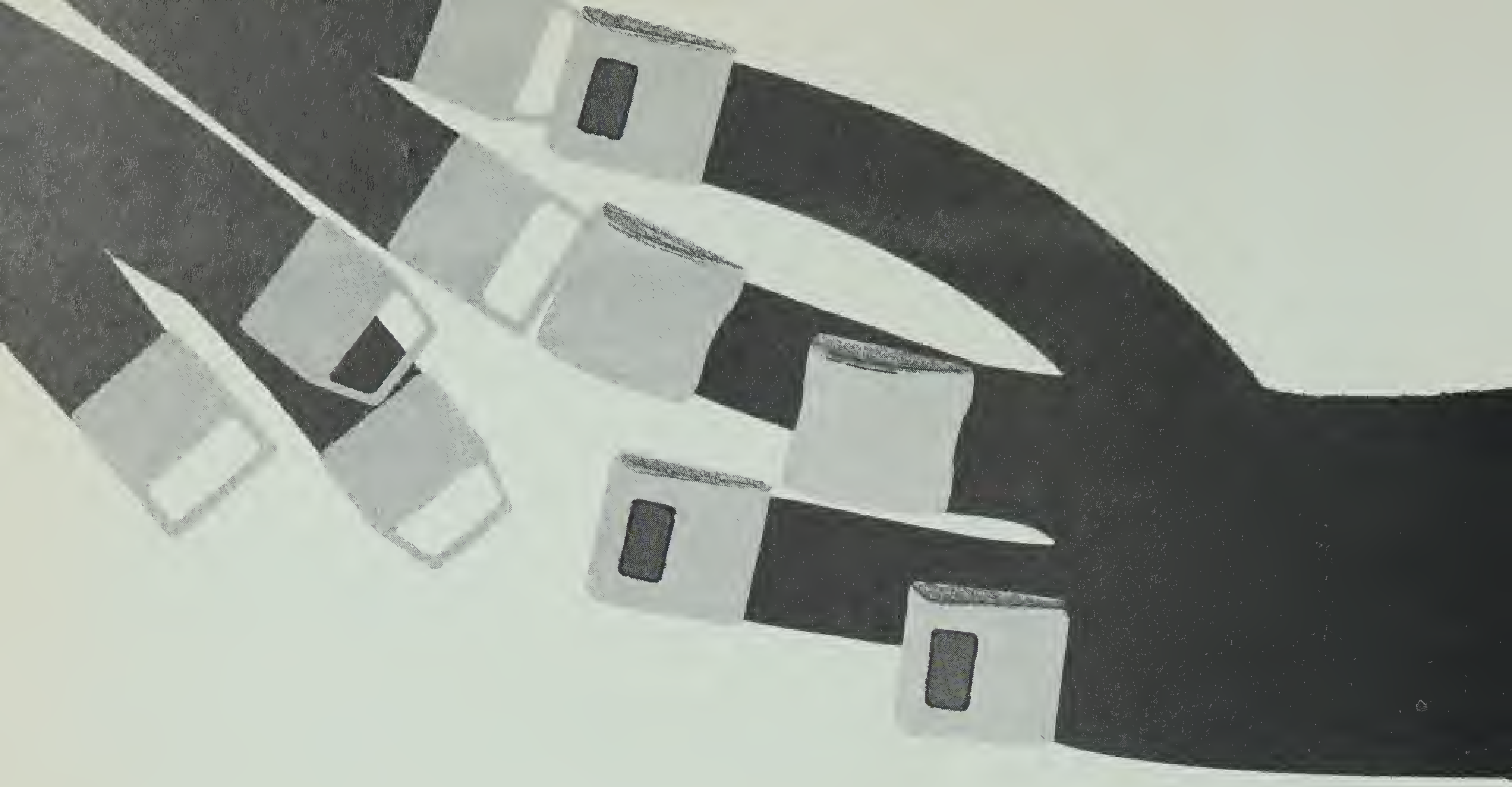
Frame 3 shows the most forward position reached by the dummy. The bag still cushions the motion. In Frames 4 and 5, the pressure of the bag returns the dummy to an upright position. It takes only 0.1 second for everything to happen in Frames 1 through 5. The bag remains fully inflated for less than 0.08 second.

1 **2**



3 **4** **5**

Figure 7–3



✓ 7–4. Look at Figure 7–2 and Figure 7–3. Do you think drivers should worry about having their vision blocked by air bags? Explain your answer.

In some collisions a car crashes two or more times. The car may hit two other cars, two different objects, or a car and an object. If the air bags fill up on the first impact, they may be partly or fully deflated by the next impact.

★ **7–5. Describe two situations in which seat belts might do better than air bags in protecting passengers.**

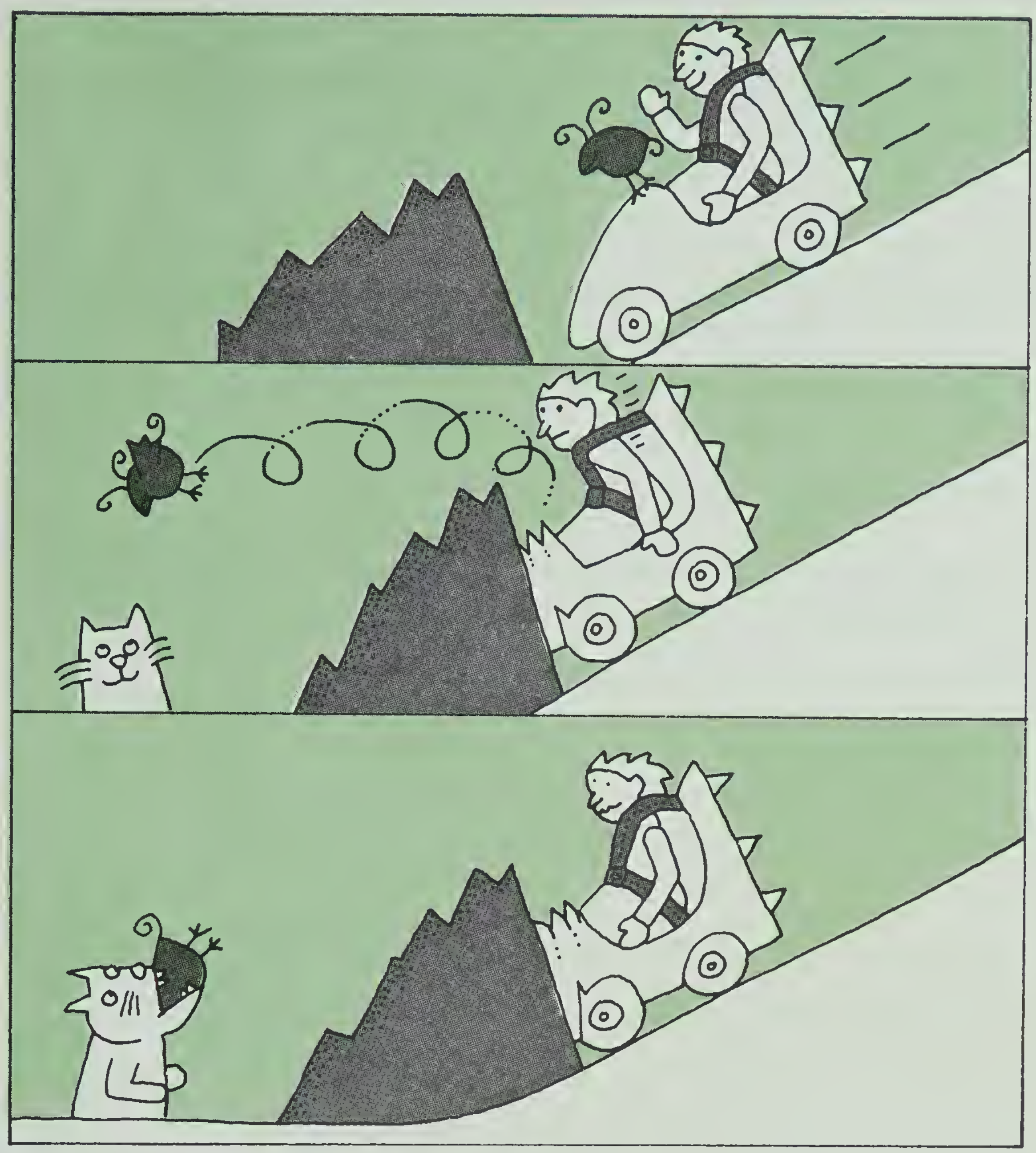
★ **7–6. What is the biggest advantage of air bags over seat belts?**

★ **7–7. There are four restraining systems listed below. Which is the most effective in a high speed head-on collision? (Assume that there is no fire or explosion.) Why is it the most effective?**

a. lap belt system
b. lap-shoulder belt system
c. lap belt system and air bag system, together
d. lap-shoulder belt system and air bag system, together

The system you chose for Question 7–7 probably would be very expensive. But your life is well worth the expense!

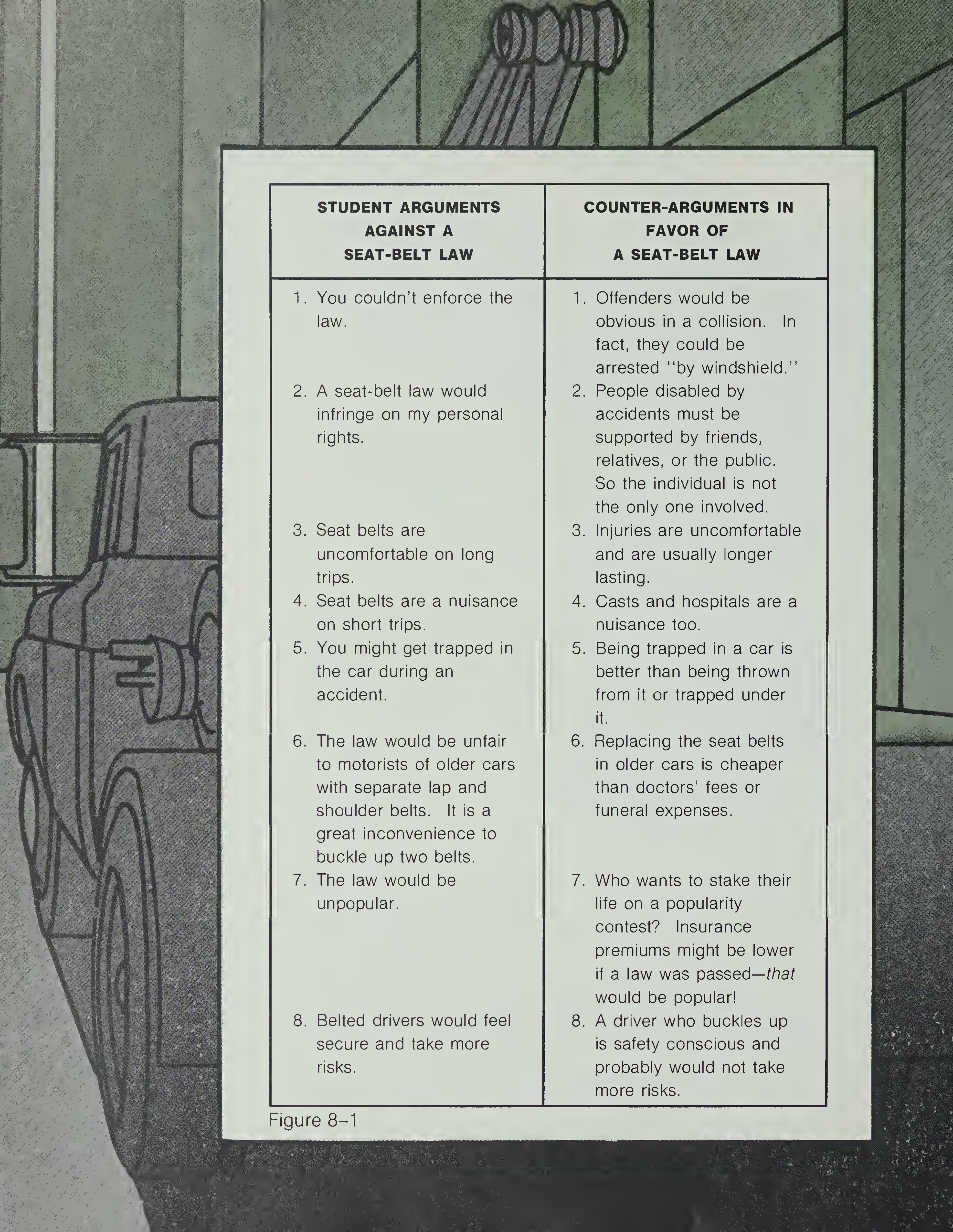
Should There Be A Law?



When something goes wrong, there's always someone around who says, "There ought to be a law." But who decides which laws are really needed? Well, in this case, you decide.

The law to consider is one that will make all motorists wear lap-shoulder seat belts. Before you decide whether or not the law is needed, listen to some student arguments against it. Find the tape for *Packaging Passengers* and listen to the band for Activity 8.

When you finish listening to the tape, review the student arguments. They are listed in Figure 8–1. Also listed is a counter-argument for each argument.



STUDENT ARGUMENTS AGAINST A SEAT-BELT LAW	COUNTER-ARGUMENTS IN FAVOR OF A SEAT-BELT LAW
1. You couldn't enforce the law.	1. Offenders would be obvious in a collision. In fact, they could be arrested "by windshield."
2. A seat-belt law would infringe on my personal rights.	2. People disabled by accidents must be supported by friends, relatives, or the public. So the individual is not the only one involved.
3. Seat belts are uncomfortable on long trips.	3. Injuries are uncomfortable and are usually longer lasting.
4. Seat belts are a nuisance on short trips.	4. Casts and hospitals are a nuisance too.
5. You might get trapped in the car during an accident.	5. Being trapped in a car is better than being thrown from it or trapped under it.
6. The law would be unfair to motorists of older cars with separate lap and shoulder belts. It is a great inconvenience to buckle up two belts.	6. Replacing the seat belts in older cars is cheaper than doctors' fees or funeral expenses.
7. The law would be unpopular.	7. Who wants to stake their life on a popularity contest? Insurance premiums might be lower if a law was passed—*that* would be popular!
8. Belted drivers would feel secure and take more risks.	8. A driver who buckles up is safety conscious and probably would not take more risks.

Figure 8–1

1. Draw two tables like those in Figure 8–2. Decide whether you agree with Argument 1 or with Counter-Argument 1 (listed in Figure 8–1). Do you *agree* or *strongly agree?* Mark an *X* in the appropriate column. Follow the same procedures for the rest of the arguments and their counter-arguments.
2. Count the number of Xs in each column and record the totals.
3. For the *Arguments,* multiply each "strongly agree" total by 5, and each "agree" total by 2. Then add the products and record the sum. Do the same for the *Counter-Arguments.*

Which sum is greater? If the sum for the arguments is greater, you agree with the students. You think there *should not be* a seat-belt law. If the sum for the counter-arguments is greater, you think there *should be* a seat-belt law.

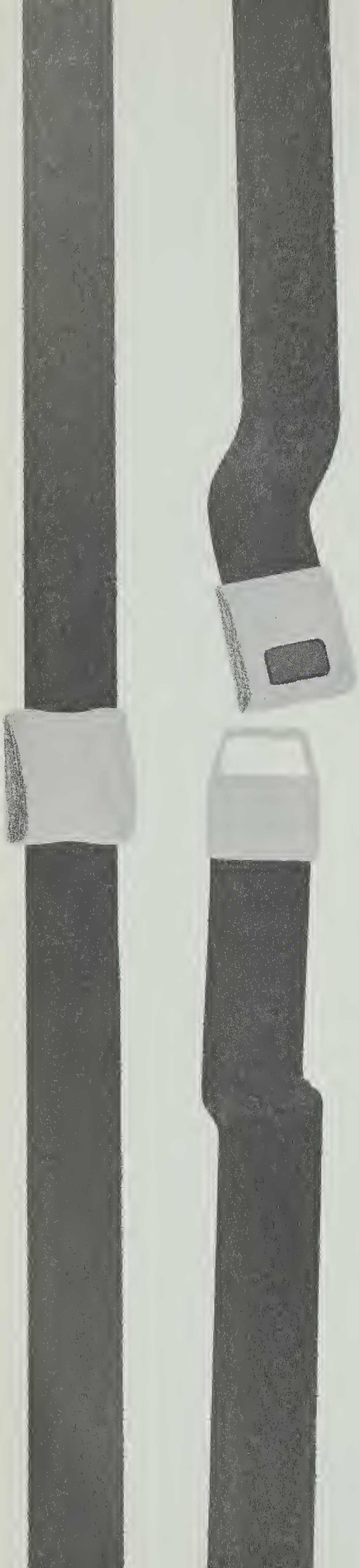
OPINION SURVEY FOR SEAT-BELT LAW

ARGUMENT	**STRONGLY AGREE**	**AGREE**
1. ______		
2. ______		
3. ______		
4. ______		
5. ______		
6. ______		
7. ______		
8.		
	Total ______	Total ______
	Multiply by 5 ______	Multiply by 2 ______
	SUM ______	

COUNTER-ARGUMENT	**STRONGLY AGREE**	**AGREE**
1. ______		
2. ______		
3. ______		
4. ______		
5. ______		
6. ______		
7. ______		
8.		
	Total ______	Total ______
	Multiply by 5 ______	Multiply by 2 ______
	SUM ______	

Figure 8–2

8–1. Do you think there should be a federal law that requires all motorists to wear seat belts? Explain the reasons for your opinion.



✓ 8–2. Look at Figure 8–1.

a. Which arguments are opinion? (They *cannot be supported* by evidence or checked for accuracy.)

b. Which counter-arguments are opinion?

✓ 8–3. Look again at Figure 8–1.

a. Which arguments are based on facts? (They *can be supported* by evidence or checked for accuracy.)

b. Which counter-arguments are based on facts?

✓ 8–4. Based on your answers to Questions 8–2 and 8–3, which are stronger, the arguments or the counter-arguments?

★ **8–5. Which of the following statements seems to be more reasonable (based on facts)?**

a. A federal law requiring motorists to wear seat belts is an infringement on your rights.

b. A federal law requiring motorists to wear seat belts is for the common good, according to accident statistics.

Suppose several years have passed and there have been a lot of changes in travel safety devices. There is a new way to package passengers. Seat belts and air bags aren't used anymore. There is even a new type of transportation. A discussion about the merits of a seat-belt law seems pretty outdated. But is it?

★ **8–6. Which of the following statements show that the seat-belt-law discussion may be useful to you in the future? Explain how the statements may be useful.**

a. There can be good arguments for all sides of a question.

b. What you do often affects others.

c. You can combine other people's ideas with your own and come to good conclusions.

d. The problems created by technology (such as cars that go too fast) often can be solved by technology (the invention of restraining devices).

e. Laws are usually made for the common good. What seems like a good law to some people may seem very unfair to others. For this reason, we must carefully consider all arguments before we make new laws or throw away old ones.

Conservation Of Energy In Crashes

When your car is running, it's exerting effort to do a job: your car is working for you. The car shown in Figure 9–1 is doing work. It's using energy to get the people from one place to another.

Figure 9–1

A car is really an energy-converting device. As soon as the car is started, the stored energy in the gasoline is converted to heat energy and motion energy. As the gasoline is ignited, the stored energy becomes heat energy. As the engine parts and transmission parts begin to move, much of the heat energy becomes motion energy. Motion energy is also called *kinetic energy.*

When the car reaches a steady speed, the engine uses energy from the gas to overcome friction. There is friction caused by the car's moving parts, by the tires against the road, and by wind resistance. As the car pushes the air aside, the motion energy becomes heat energy. The air carries away this heat energy. When you brake the car to slow it down, the car's motion energy is changed to heat energy in the brakes or possibly the tires.

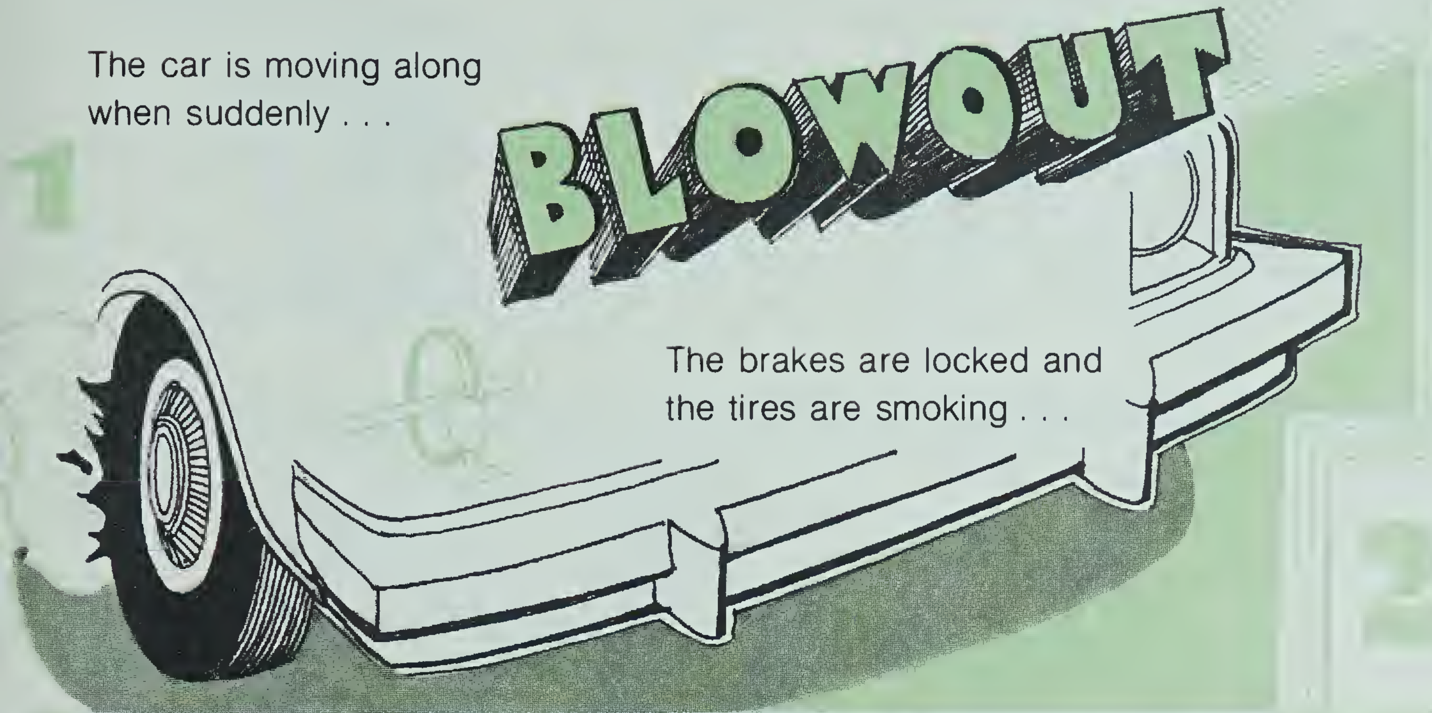
It may seem that some energy is lost from the time the car is started until it is stopped. But energy is not lost. It is changed from one form to another. The chemical energy of the gasoline is changed to heat and motion energy. Then a lot of the motion energy is changed to heat energy: warm air, warm water, warm metal, and so on.

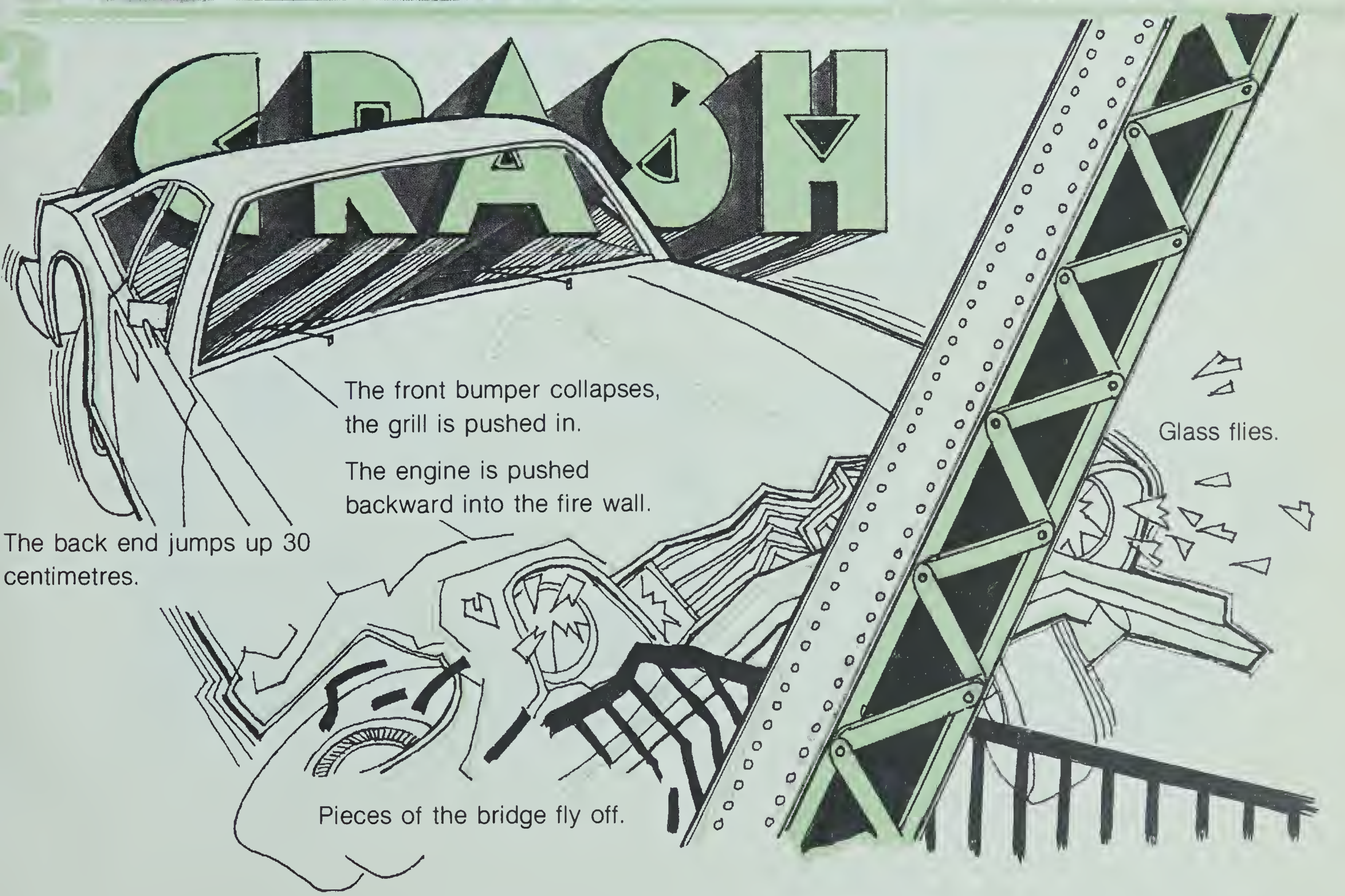
The car example is not the only case in which energy changes in form but not in amount. In fact this is true of all energy changes in all things, natural or synthetic. Scientists sum this up as the law of conservation of energy:

Energy can be changed from one form to another, but it cannot be created or destroyed.

✓ 9-1. Some forms of energy are shown in the drawing. Which ones are used to move the car?

How does the law of conservation of energy apply to car crashes? A lot of things are changed during a crash. Let's investigate some of these changes. Get the tape for *Packaging Passengers* and listen to the band for Activity 9. You may want to look at Frames 1–6, here and on the next page, as you listen.





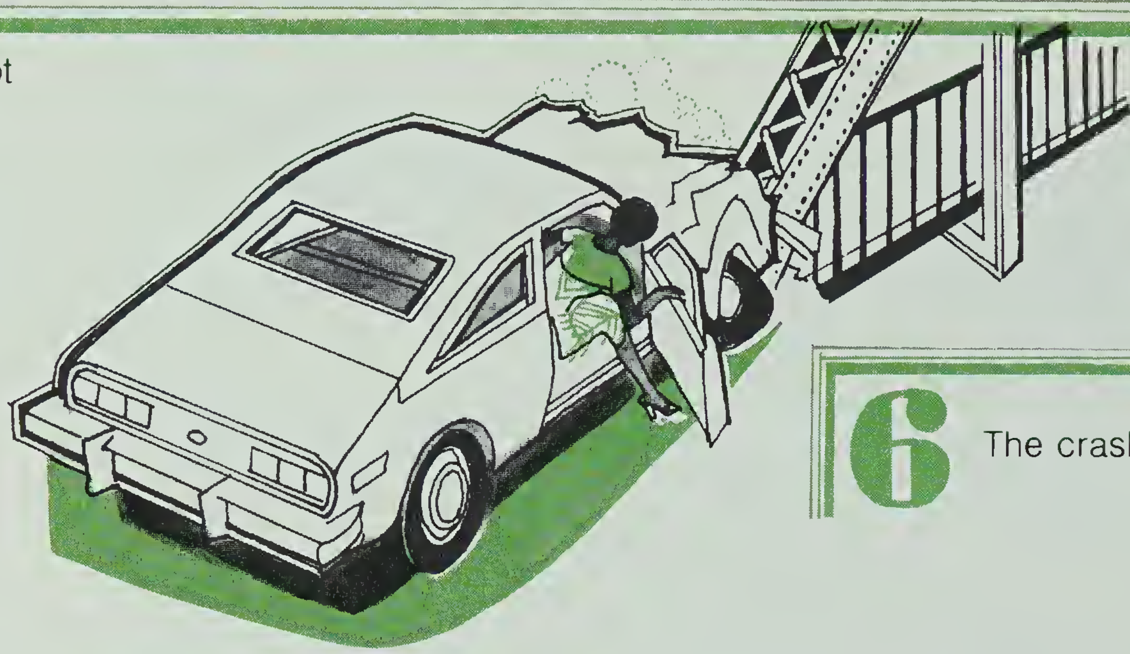
4

The passengers are thrown forward.

The air bags inflate in time! The passengers are pushed back into their seats. Objects in the car fly forward: some fly out of the window, others hit the windshield and reverse direction.

5

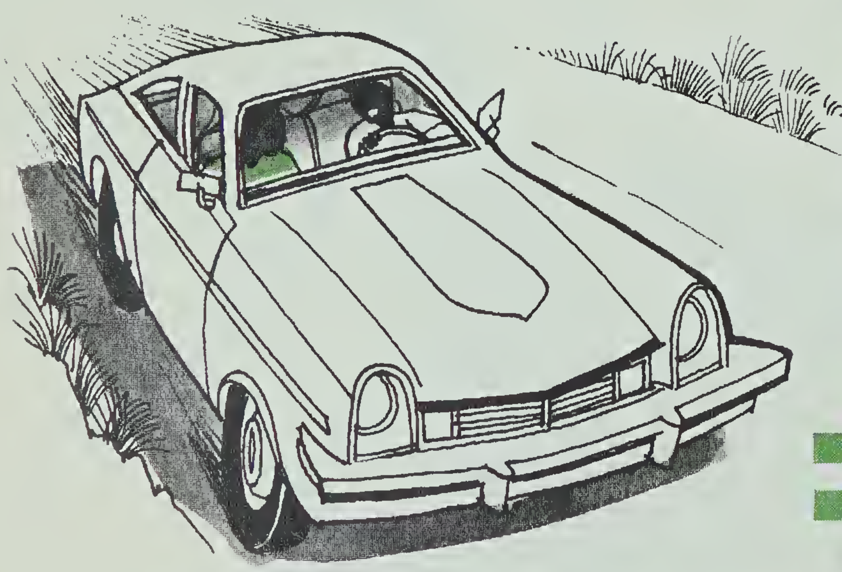
There's the smell of hot rubber, steam, charred paint, and burning insulation. The dust is settling and the people are beginning to move around.



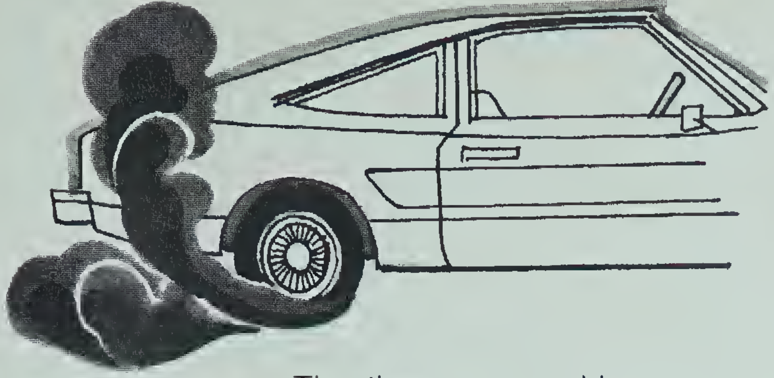
6

The crash is over!

During the crash, the energy of motion of the moving car was changed to other forms of energy. There was no energy created and no energy destroyed: the energy was conserved.



The amount of motion energy before the crash . . . equals the amount of energy transferred to other parts of the car and the bridge.



The tires are smoking.

The energy of motion of the car is changed to friction which is changed to heat. (The friction occurs between the tires and the pavement.)

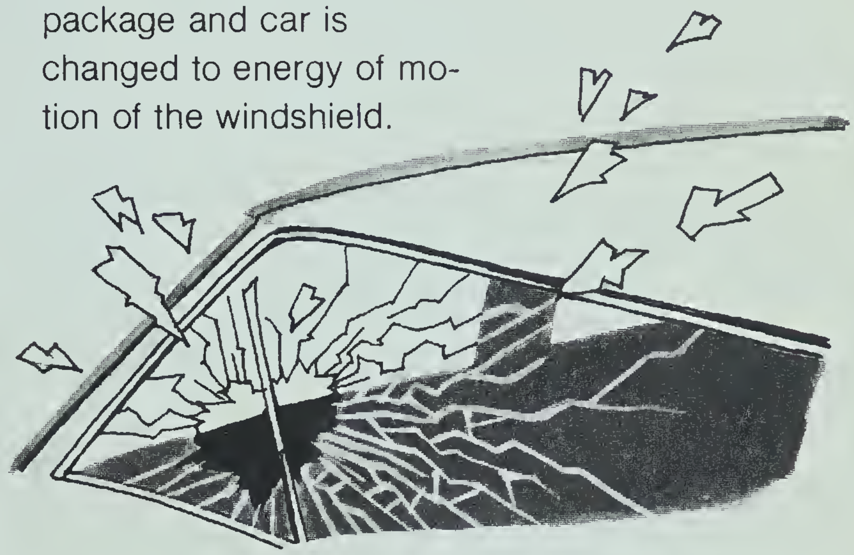
The engine is pushed backward into the fire wall.

The energy of motion of the car is changed to energy of motion of the engine.

Pieces of the bridge fly off.

The energy of motion of the car is changed to energy of motion of the bridge.

Glass flies as package hits windshield. Some of the energy of motion of the package and car is changed to energy of motion of the windshield.



★ 9–2. The passengers shown on pages 39 and 40 were hardly injured. Before the crash they were traveling at the same speed as the car. At the end their motion had stopped. What happened to the energy of motion of the passengers?

★ 9–3. In your own words, state how the law of conservation of energy applies to car crashes.

This may be the first time you've met the law of conservation of energy. If so, don't worry if the meaning isn't completely clear. You'll study conservation of energy again in other minicourses. However, if you've seen this law before, and are feeling uneasy about it, you may want to read *Resource Unit 18*. It describes conservation of energy in more detail.

Advanced

Activity 10 Planning

Activity 11 Page 43

Objective 10: Calculate the total momentum and total velocity of automobiles in inelastic collisions.

Sample Question: A 2000-kilogram (4400 pound) car is traveling 30 kilometres (18 miles) an hour. It collides head-on with a 4000-kilogram (8800 pound) car traveling at 40 kilometres (24 miles) an hour in the opposite direction. What is the total momentum and total velocity after the collision? In what direction is the momentum?

Activity 12 Page 52

Objective 11: Use vectors to calculate the resultant force on a car traveling around a curve.

Sample Question: Suppose you and your car have a total mass of 1000 kg. Suppose you are traveling at 80 km per hour and come into a 150-metre radius curve. You speed up 4 metres per second in one second. What resultant force (in newtons) will be exerted on your car by the road? Will your car skid on dry concrete? (Use Figures 12–5, 12–6, and 12–8.)

Activity 13 Page 57

Objective 12: Apply Newton's Second Law of Motion to automotive situations involving acceleration.

Sample Question: A car is stalled. Four people push it to get it started. The mass of the car is 1000 kg including the driver. The car will start once it's going 14.4 kilometres per hour or 4 metres per second. How much force do the people pushing have to apply so that the car will start after 30 seconds?

Answers

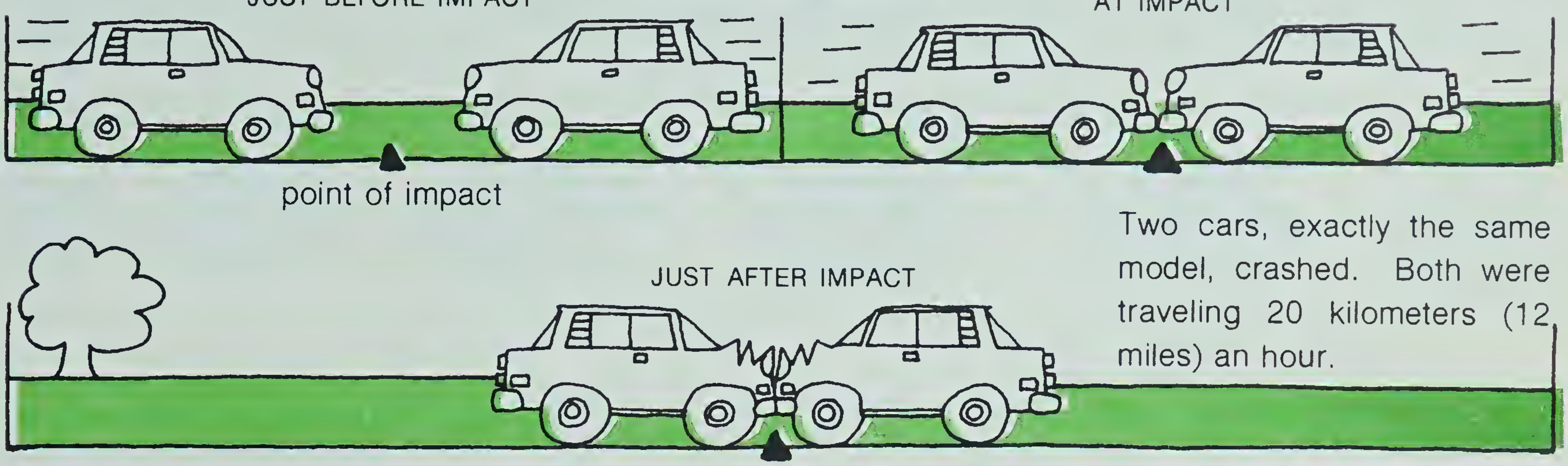
10. —16.7 km/h in the direction that the 4000-kilogram car was traveling.

11. About 5200 newtons. No, it will not skid. 12. About 133 newtons.

Calculating Collision Momentum

Three different collisions are shown in Figures 11–1, 11–2, and 11–3. In each collision, the vehicles crashed head-on while traveling in opposite directions. The vehicles' speeds before impact are shown in kilometres per hour (km/h). If you need to review metric units, read *Resource Unit 14.*

COLLISION 1

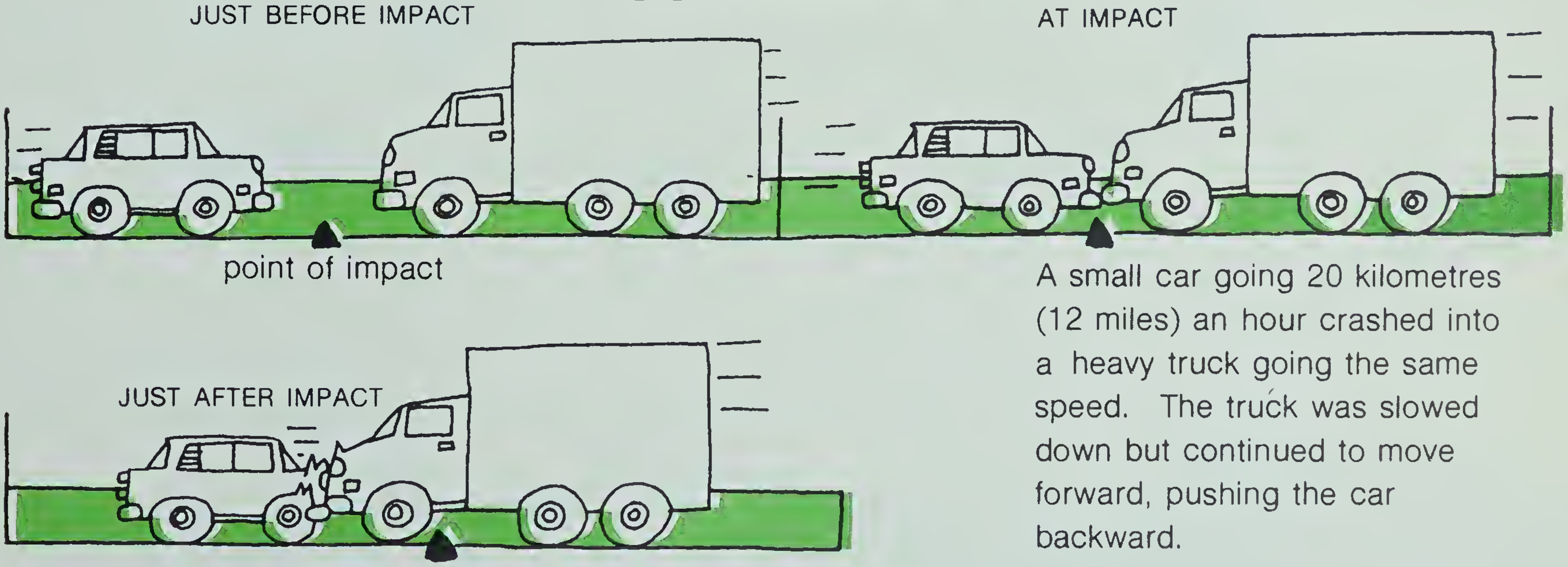


Two cars, exactly the same model, crashed. Both were traveling 20 kilometers (12 miles) an hour.

Figure 11—1

✔ 11–1. In Collision 1, where did both cars stop after they crashed?

COLLISION 2



A small car going 20 kilometres (12 miles) an hour crashed into a heavy truck going the same speed. The truck was slowed down but continued to move forward, pushing the car backward.

Figure 11–2

11-2. In Collision 2, where did both the car and truck stop after they crashed?

COLLISION 3

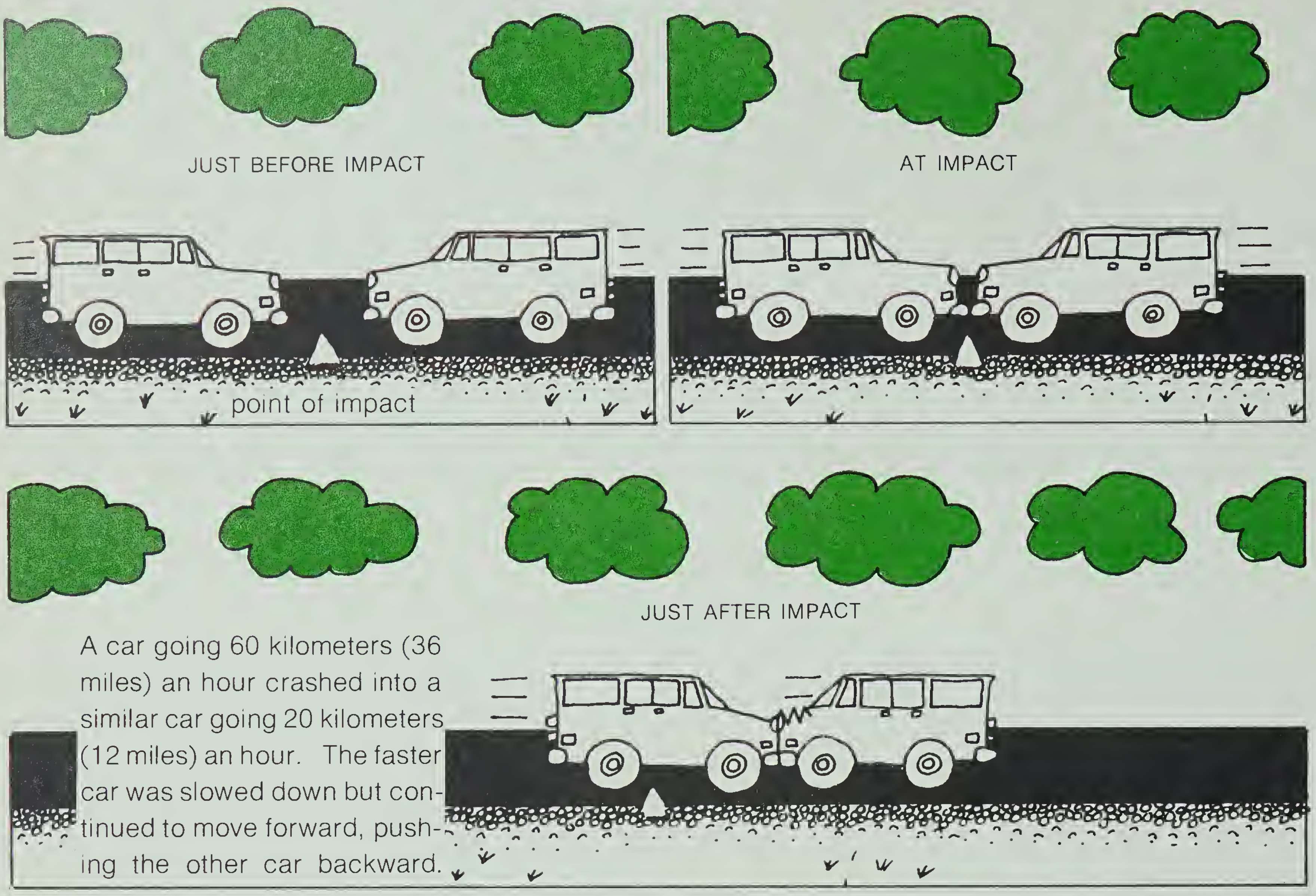


Figure 11-3

11-3. In Collision 3, where did both cars stop after they crashed?

In a collision, the effect a vehicle has on the object it hits depends on two things:

1. its mass
2. its speed

11-4. In Collision 2, why did the truck have a greater effect than the car? (Remember, both were moving at the same speed.)

★ **11-5. In Collision 3, why did one car have a greater effect than the other car? (Remember, both cars had the same mass.)**

You've seen the effect a moving object has when it hits another object. This effect depends on the speed and mass of the moving object. Newton called the combination of speed and mass the *quantity of motion.* It is what physicists now call *momentum.* And physicists have a formula for momentum:

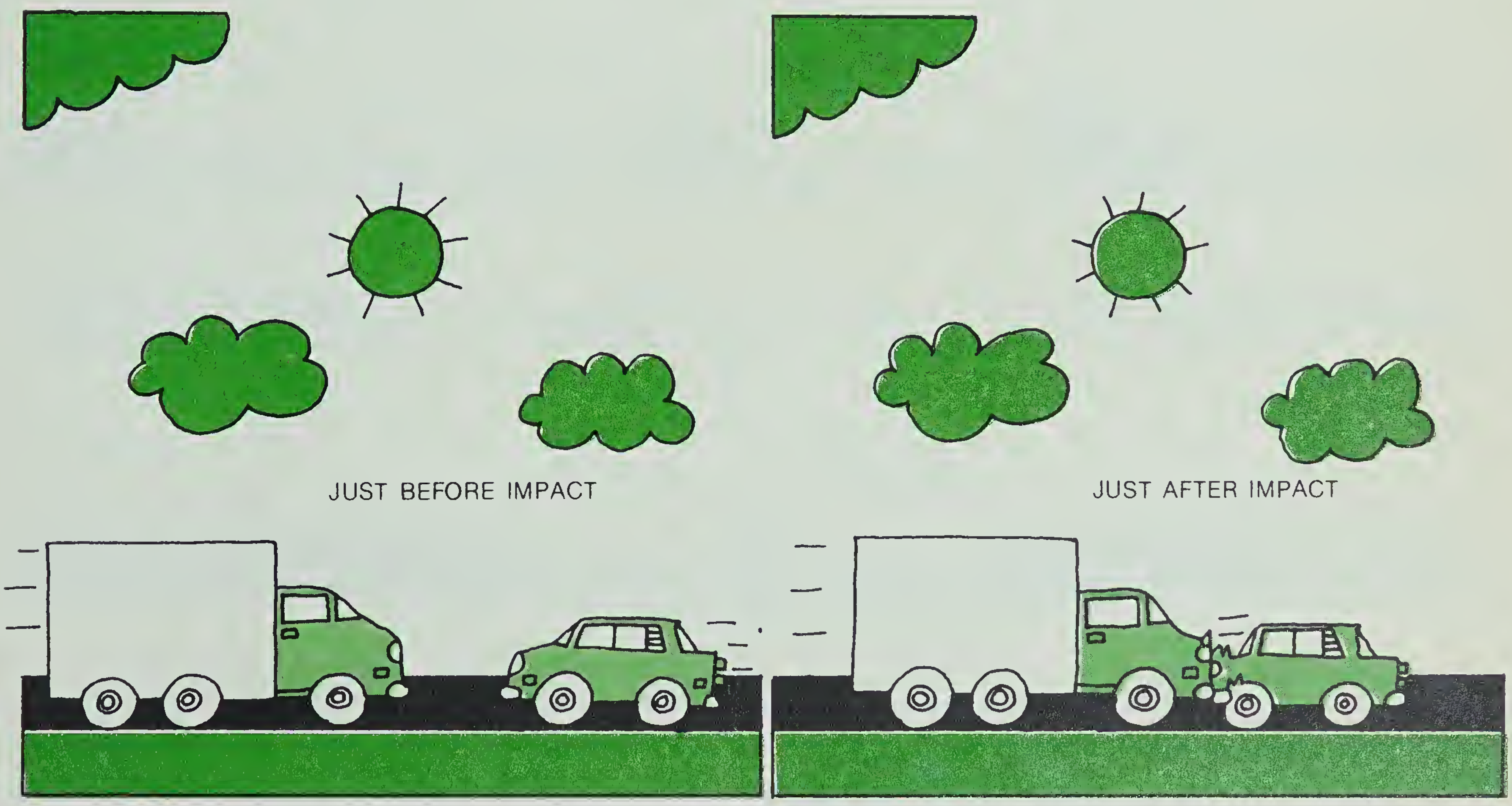
$$\begin{aligned} \text{momentum} &= \text{mass} \times \text{velocity} \\ &= m \times \vec{v} \end{aligned}$$

The mass *m* is the amount of matter that makes up a body. The velocity $\vec{v}$ of a body is often called its speed. But velocity is really the *speed* of a body in a particular *direction.* (The arrow over the *v* shows that the motion has direction.)

In a collision, the total momentum just before impact is the same as the total momentum just after impact. This is known as the *law of conservation of momentum.* The law is true no matter how many bodies are involved. And the "total momentum" is *the sum of the momentums of all the bodies involved.*

LAW OF CONSERVATION OF MOMENTUM

TOTAL MOMENTUM JUST BEFORE IMPACT = TOTAL MOMENTUM JUST AFTER IMPACT



Momentum of truck + Momentum of car = Momentum of truck + Momentum of car

✓ 11–6. Suppose two cars of different mass and velocity collide head-on. Is the momentum conserved? Why?

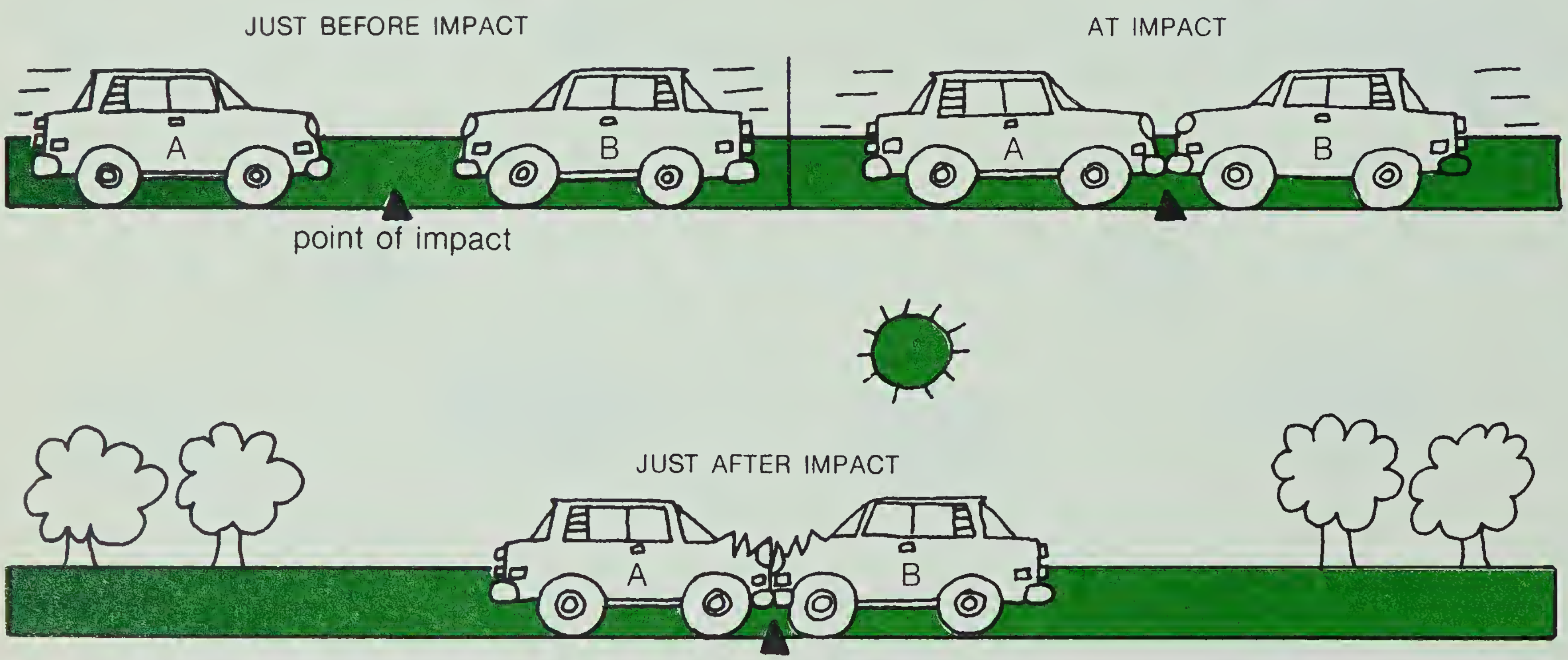
Now, let's apply the idea of conservation of momentum to the three collisions described earlier. To simplify the discussion, we'll make the following assumptions about the collisions:

1. The vehicles were the only bodies involved.
2. The vehicles were moving in opposite directions on one lane of a two-lane road.
3. After impact, the vehicles remained locked together and did not bounce apart.

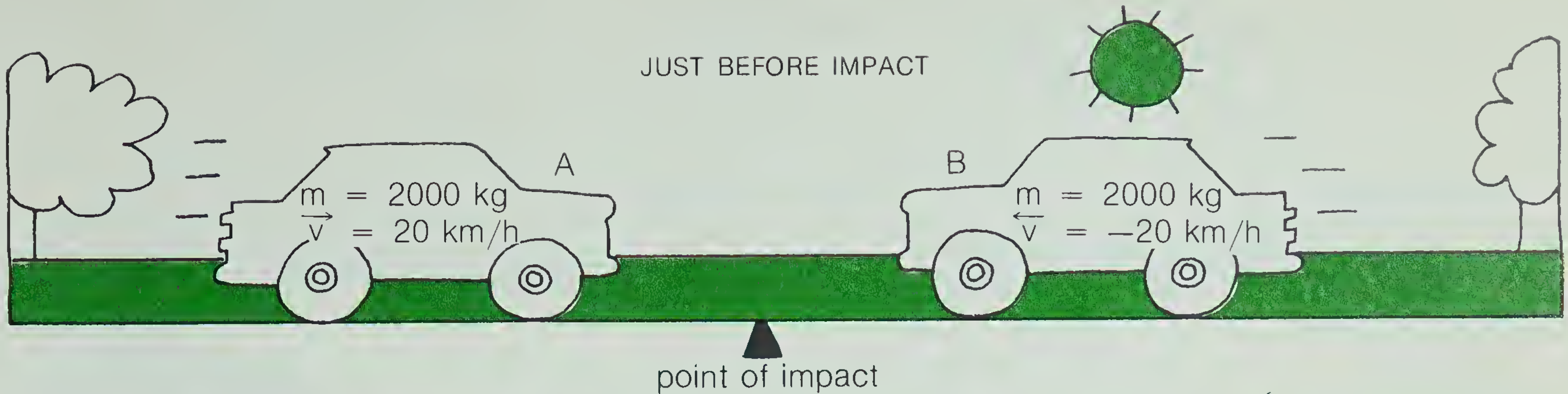
Real crashes, of course, rarely fit these assumptions. But the assumptions help us to investigate a head-on crash.

In each collision, the velocities of the two vehicles were opposite in direction. We'll call one direction *positive* and the other direction *negative.* So the velocities were also positive and negative. In this activity we'll use $\overrightarrow{V}$ for positive velocity, and $\overleftarrow{V}$ for negative velocity. The way the arrow points indicates positive (⟶) or negative (⟵) velocity. Now let's go back to the collisions.

COLLISION 1



In Collision 1, the vehicles have equal masses. Before impact, they were traveling at the same speed. Suppose the mass of each car was 2000 kilograms (4400 pounds) and the speed was 20 kilometres (12 miles) per hour. What was the total momentum before impact?



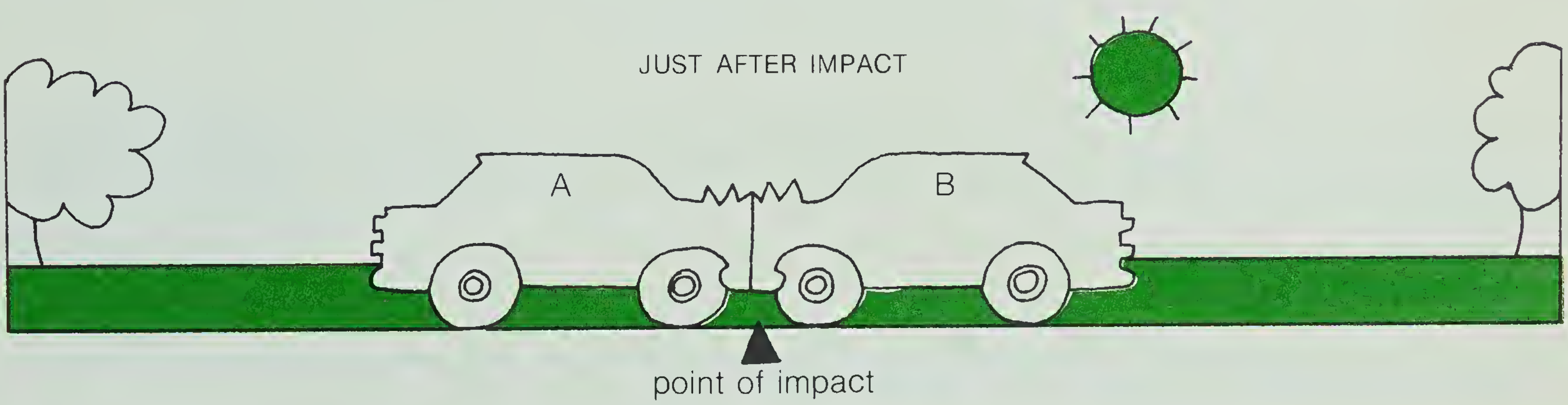
Momentum of A $= m \times \vec{v}$
$= (2000 \text{ kg}) \times (20 \text{km/h})$
$= 40{,}000 \text{ kg}{\cdot}\text{km/h}$

Momentum of B $= m \times \overleftarrow{v}$
$= (2000 \text{ kg}) \times (-20 \text{ km/h})$
$= -40{,}000 \text{ kg}{\cdot}\text{km/h}$

Total Momentum = Momentum of A + Momentum of B
$= (40{,}000 \text{ kg}{\cdot}\text{km/h}) + (-40{,}000 \text{ kg}{\cdot}\text{km/h})$
$= 0 \text{ kg}{\cdot}\text{km/h}$

The total momentum of the two cars, before impact, was zero. Does that seem strange to you? Remember, the cars were of the same mass and were going the same speed. But they were going in opposite directions!

Predict the total momentum of the two cars *after* impact. Base your prediction on the law of conservation of momentum. Then calculate the total momentum. Notice that neither car moved after impact. So, after impact, the velocity of each car was zero.



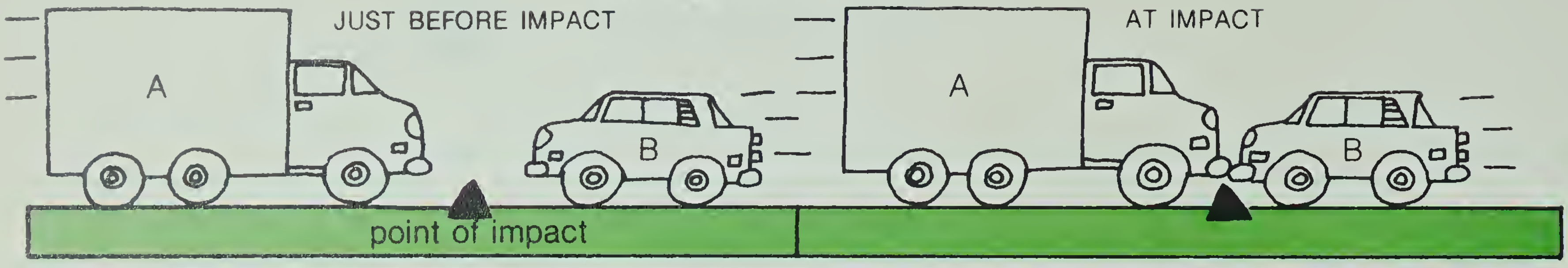
Momentum of A $= m \times \vec{v}$
$= (2000 \text{ kg}) \times (0 \text{ km/h})$
$= 0 \text{ kg}{\cdot}\text{km/h}$

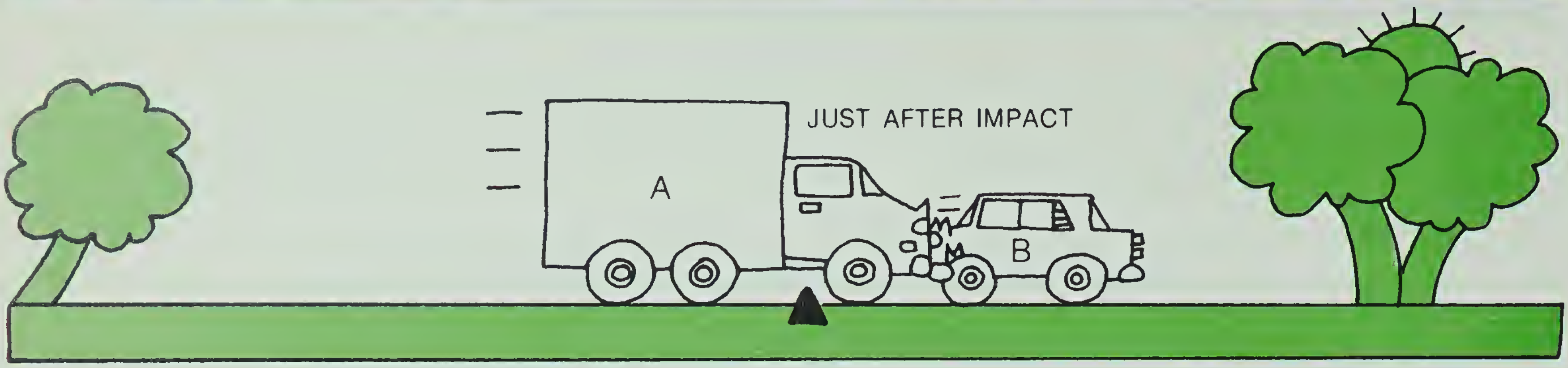
Momentum of B $= m \times \overleftarrow{v}$
$= (2000 \text{ kg}) \times (0 \text{ km/h})$
$= 0 \text{ kg}{\cdot}\text{km/h}$

Total Momentum = Momentum of A + Momentum of B
$= (0 \text{ kg}{\cdot}\text{km/h}) + (0 \text{ kg}{\cdot}\text{km/h})$
$= 0 \text{ kg}{\cdot}\text{km/h}$

✔ 11-7. Was the total momentum before impact equal to the total momentum after impact?

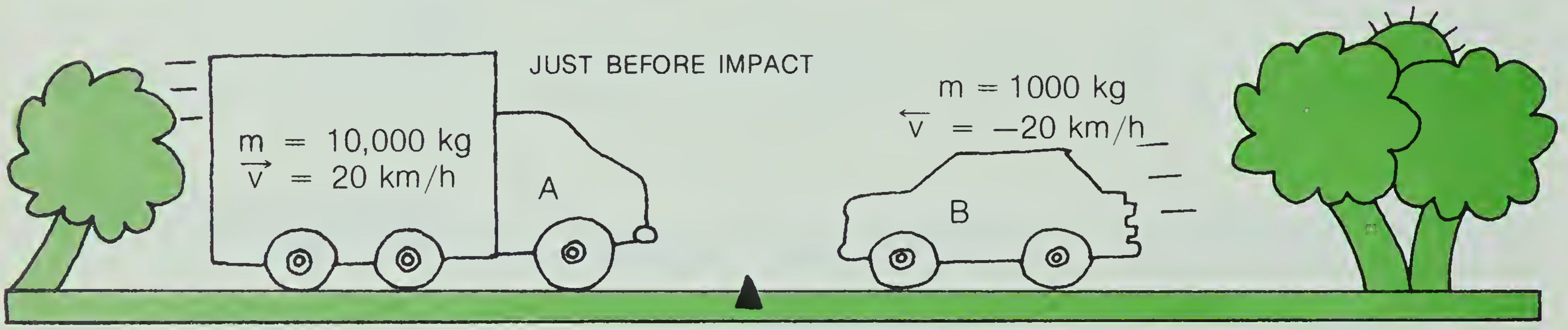
COLLISION 2





In Collision 2, the vehicles have different masses. Before impact, they were traveling at the same speed. Suppose the truck's mass was 10,000 kilograms (22,000 pounds) and the car's was 1000 kilograms (2200 pounds). And suppose both the truck and car were going 20 kilometres (12 miles) an hour. What was their combined velocity and direction immediately after impact?

We can find the combined velocity and direction if we know the combined momentum after impact. Remember, total (combined) momentum is conserved; it is the same before or after impact. So if we find the total momentum before impact, we'll know the total momentum after impact.

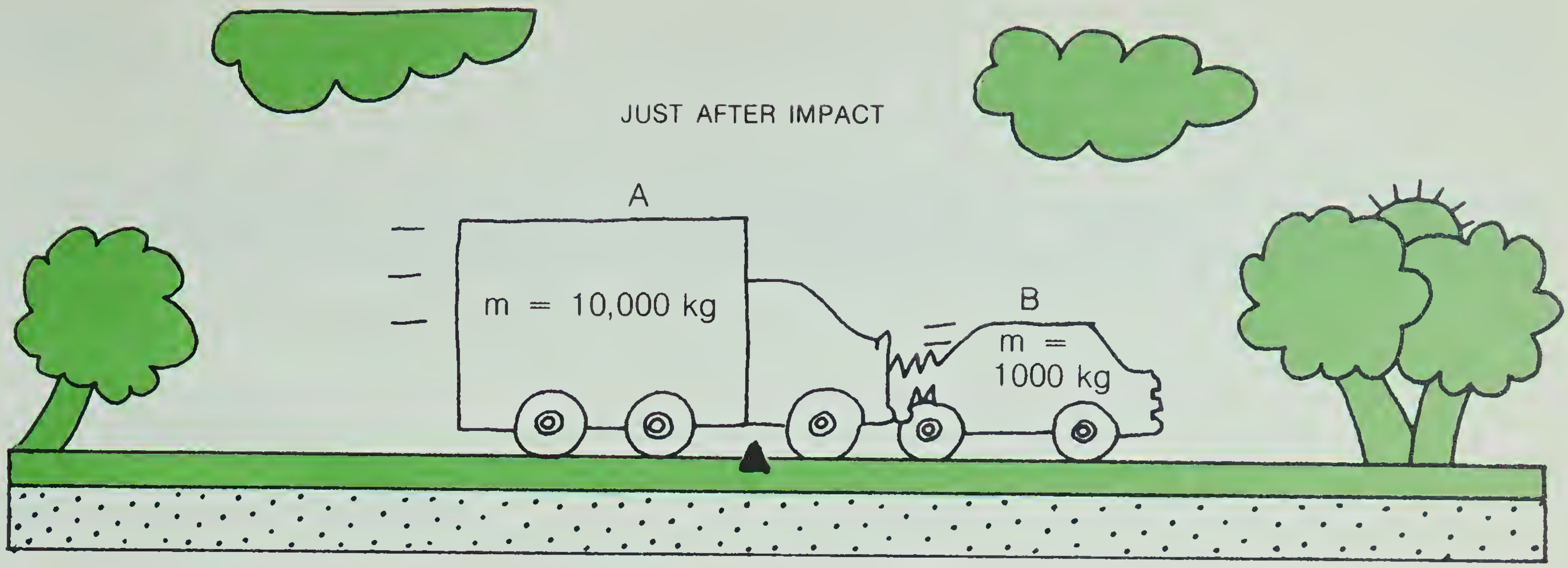


$$\begin{aligned}\text{Momentum of A} &= m \times \vec{v} \\ &= (10{,}000 \text{ kg}) \times (20 \text{ km/h}) \\ &= 200{,}000 \text{ kg}\cdot\text{km/h}\end{aligned}$$

$$\begin{aligned}\text{Momentum of B} &= m \times \overleftarrow{v} \\ &= (1000 \text{ kg}) \times (-20 \text{ km/h}) \\ &= -20{,}000 \text{ kg}\cdot\text{km/h}\end{aligned}$$

$$\begin{aligned}\text{Total Momentum} &= \text{Momentum of A} + \text{Momentum of B} \\ &= (200{,}000 \text{ kg}\cdot\text{km/h}) + (-20{,}000 \text{ kg}\cdot\text{km/h}) \\ &= 180{,}000 \text{ kg}\cdot\text{km/h}\end{aligned}$$

Total momentum before and after impact is 180,000 kg•km/h. Since this number is positive, the total momentum is in a positive direction. That's the direction the truck was traveling before and after impact. Now find the total velocity after impact.



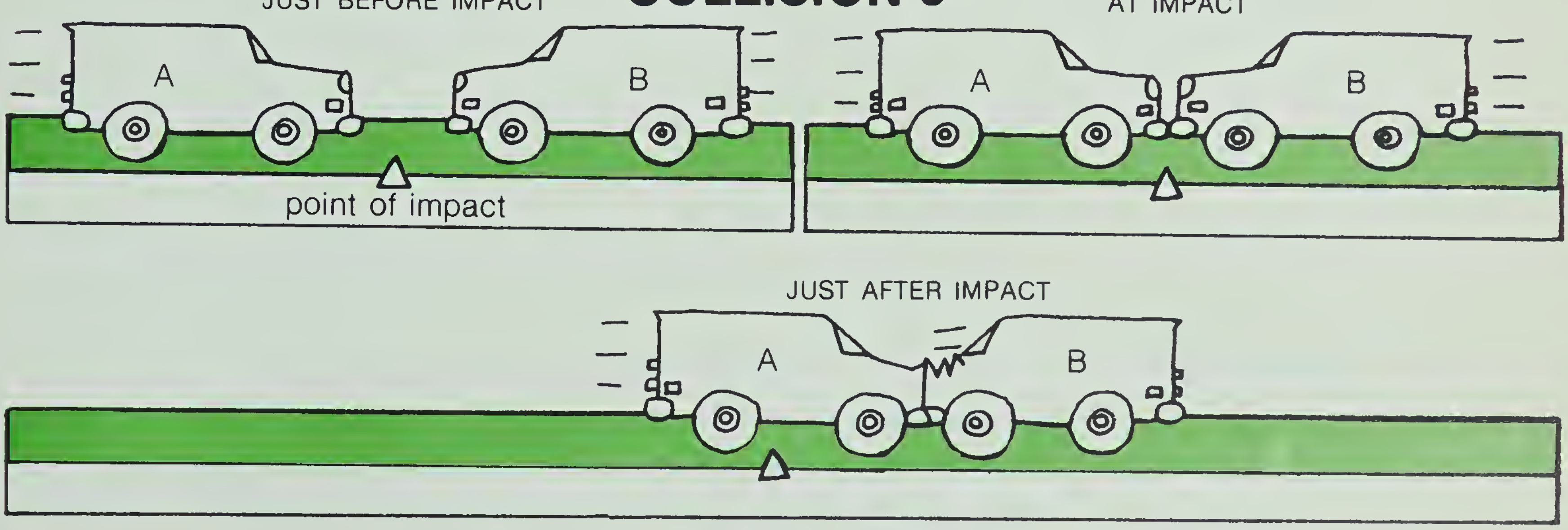
$$\text{Total Momentum} = \text{Total mass} \times \text{Total velocity}$$

$$\text{or Total velocity} = \frac{\text{Total Momentum}}{\text{Total mass}} = \frac{180{,}000\ \text{kg}\cdot\text{km/h}}{11{,}000\ \text{kg}} = 16.4\ \text{km/h}$$

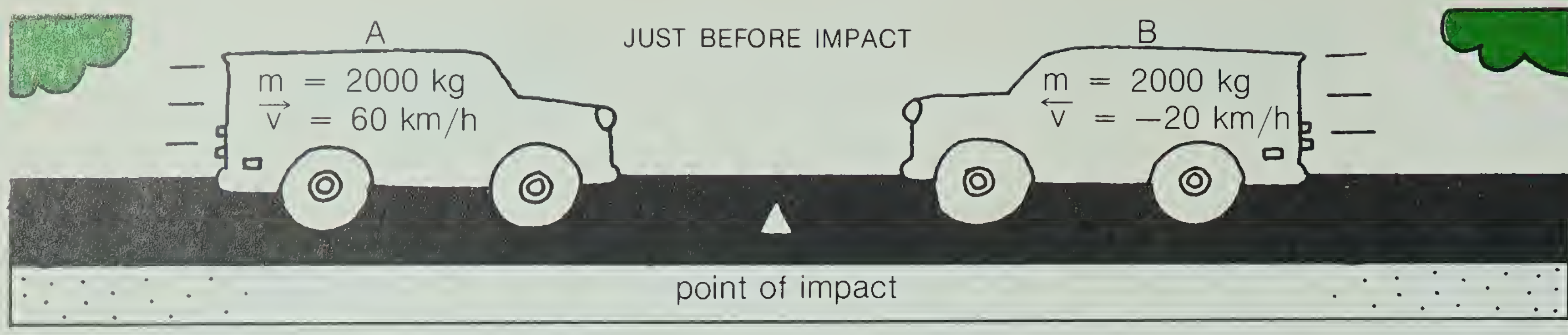
The total velocity after impact was about 16 kilometres (10 miles) an hour in the direction that the truck was traveling.

✔ 11–8. Would the combined mass (both vehicles) continue to move at this velocity? Explain.

COLLISION 3



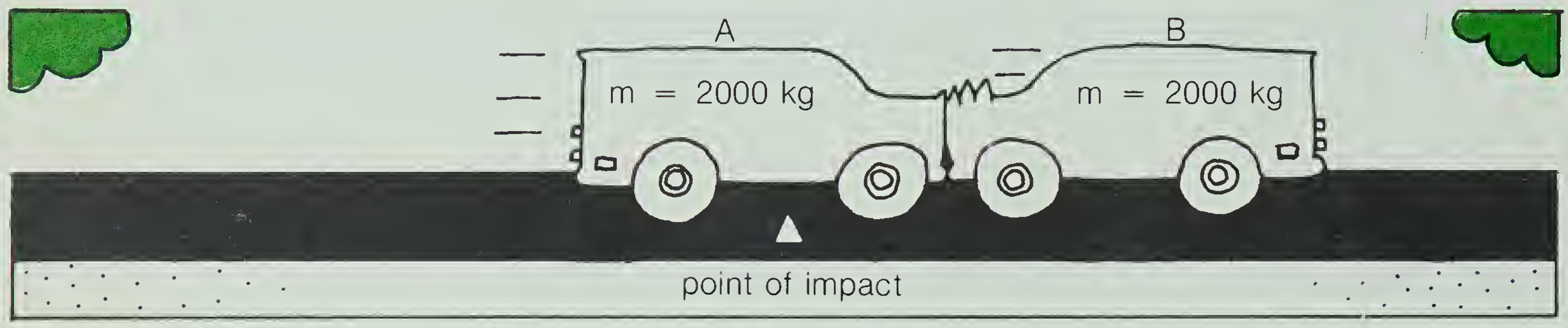
In Collision 3, the vehicles have equal masses. They were traveling at different speeds before impact. Suppose the mass of each car was 2000 kilograms (4400 pounds). Suppose Car A's speed was 60 kilometres (36 miles) an hour and Car B's was 20 kilometres (12 miles) an hour. What was their combined velocity and direction immediately after impact?



$$\text{Momentum of A} = m \times \vec{v} = (2000\ \text{kg}) \times (60\ \text{km/h}) = 120{,}000\ \text{kg·km/h}$$

$$\text{Momentum of B} = m \times \overleftarrow{v} = (2000\ \text{kg}) \times (-20\ \text{km/h}) = -40{,}000\ \text{kg·km/h}$$

$$\text{Total Momentum} = (120{,}000\ \text{kg·km/h}) + (-40{,}000\ \text{kg·km/h}) = 80{,}000\ \text{kg·km/h}$$



$$\text{Total Momentum} = \text{Total mass} \times \text{Total velocity}$$

$$\text{or Total velocity} = \frac{\text{Total Momentum}}{\text{Total mass}} = \frac{80{,}000\ \text{kg·km/h}}{4000\ \text{kg}} = 20\ \text{km/h}$$

After impact, the vehicles traveled at 20 kilometres (12 miles) per hour. They moved in the direction that Car A (the faster car) was heading before impact.

The following questions relate to conservation of momentum and collisions. Answer the questions and show all calculations.

PROBLEMS

★ 11–9. A 2000-kilogram (4400-pound) car is traveling 20 kilometres (12 miles) an hour. It collides head-on with a 1000-kilogram (2200-pound) sports car traveling 60 kilometres (36 miles) an hour in the opposite direction. What is the total velocity and direction after impact?

★ 11–10. A 10,000-kilogram (22,000-pound) truck is traveling 50 kilometres (30 miles) an hour. It collides into the back of a stopped car. The car's mass is 2000 kilograms (4400 pounds). What is the total velocity after impact? In what direction do the vehicles move?

★ 11-11. A motorcycle is traveling 60 kilometres (36 miles) an hour. It collides head-on with a car traveling 40 kilometres (24 miles) an hour in the opposite direction. The mass of the cycle and rider is 800 kilograms (1760 pounds). The mass of the car and driver is 4000 kilograms (8800 pounds). What is the total velocity after collision? In what direction do the vehicles move?

MOMENTUM and SAFETY DESIGN

In a car crash, the severity of injuries is related to the change in velocity of the vehicles. Consider the crash between the truck and car described in Collision 2. In this crash, the truck and car collided head-on. Each was traveling at 20 kilometres (12 miles) an hour. After the collision, the vehicles moved 16 kilometres (10 miles) an hour in the direction of the truck. The truck (and its driver) went from 20 to 16 kilometres an hour. This change in velocity was 4 kilometres (2 miles) an hour. But the car (and its driver) went from 20 kilometres an hour in one direction to 16 kilometres an hour in the opposite direction. This was a change in velocity of 36 kilometres (22 miles) an hour. The change in velocity for the car was nine times greater than that for the truck. The driver of the car was far more likely to suffer serious injury than the driver of the truck.

This is a major problem in car-safety design. In a crash, a driver of a heavy vehicle is protected. The vehicle plows on like a tank. But, while the vehicle protects its own driver, it greatly increases the chance of injury to drivers of smaller cars.

✓ 11-12. Consider what you have learned in this minicourse. Then describe how passengers in a small car could be better protected from injury during a crash with a larger vehicle.

✓ 11-13. Why might a glancing collision be less destructive to a person and a vehicle than a head-on collision? (In a *glancing* collision, a vehicle hits an object at an angle and then bounces off the object.)

ANSWERS 11-9. About 7 km/h in the direction the sports car was traveling. 11-10. About 42 km/h in the direction the truck was traveling. 11-11. About 23 km/h in the direction the car was traveling.

Speeding Around Curves

Believe it or not, a racing car driver is constantly using principles of physics to make judgments. When a speeding car goes into a curve, the car must stay on the road. If the driver misjudges a curve, the car will skid. If the driver misjudges the road's surface, the car will skid. Later in this activity, you'll get a chance to make some of these judgments.

What principles are actually used in "racing-car physics"? How are they used? Well, the forces acting on the car are studied. The direction of a force is shown by an arrow called a *vector.* The size of the force is shown by the length of the vector. The scale that relates the length of the vector to the size of the force is up to you. It really depends on how much space you have for your drawing. But all vectors in the same drawing must be in the same scale.

Two vectors $\mathbf{F_1}$ and $\mathbf{F_2}$ are shown in Figure 12–1. The scale used is 1 centimetre for 1000 newtons.

Figure 12–1

✔ 12–1. In Figure 12–1, which vector shows a force of 6,000 newtons to the right?

Draw the two force vectors, $\mathbf{F_1}$ and $\mathbf{F_2}$. Then draw a parallelogram using $\mathbf{F_1}$ and $\mathbf{F_2}$ as sides. The dashed lines in the drawing are the sides of the parallelogram. Side x is the same length as $\mathbf{F_1}$ and side y is the same length as $\mathbf{F_2}$. The diagonal is the **resultant vector.**

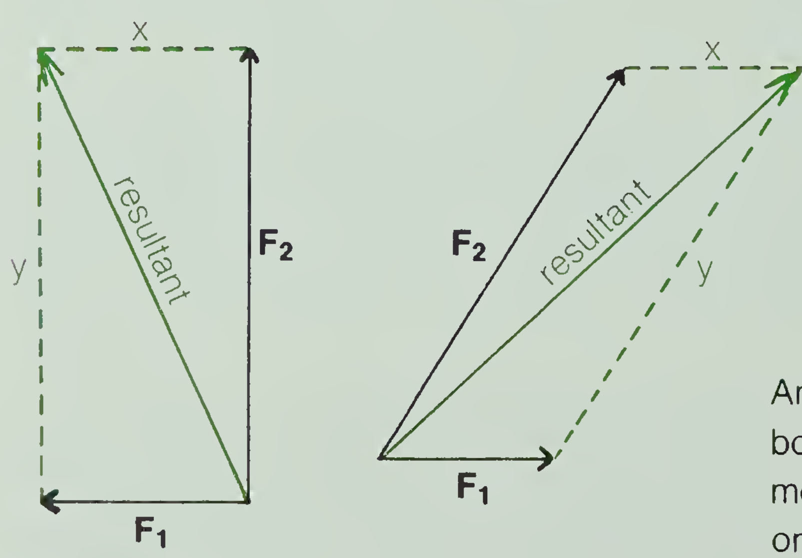


Figure 12–2

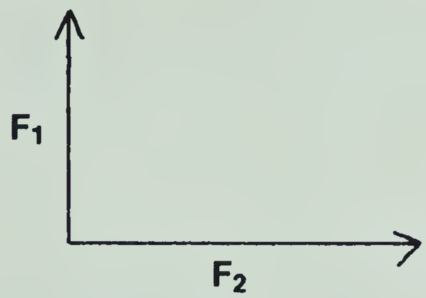
An object acted on by both $\mathbf{F_1}$ and $\mathbf{F_2}$ would move as though acted on only by the resultant force.

Two forces with different directions act on a turning car. The result of the forces determines the speed and direction in which the car will move. This result is shown by a single vector called the *resultant vector*. It is the sum of the two force vectors. Figure 12–2 shows how to find the resultant vector.

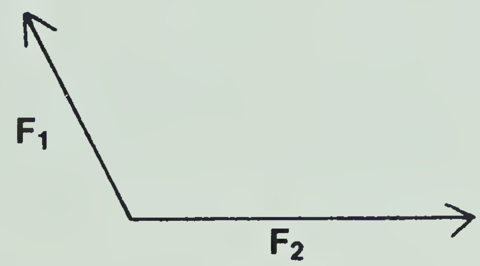
✔ 12–2. Look at Figure 12–2. What is the measure, in newtons, of the resultant vectors? (1 centimetre represents 1000 newtons.)

★ **12–3. Place a clean piece of paper over the vectors shown. Copy the vectors on the paper and draw the resultant vectors. What is the measure, in newtons, of the resultant vectors? (1 centimetre represents 1000 newtons.)**

a.



b.



A racing car going into a curve is shown in Figure 12–3. The vector $\mathbf{F_1}$ shows the forward speed of the car and the direction that the car is heading as it approaches the curve. The car will continue to go in this direction unless acted upon by an outside force. (Remember Newton's first law of motion?) But the driver turns the wheels. The force of the road against the tires changes the direction of motion of the car. There is a change in velocity. This change is shown by the vector $\mathbf{F_2}$. The car moves in the direction of the resultant vector $\mathbf{F_3}$.

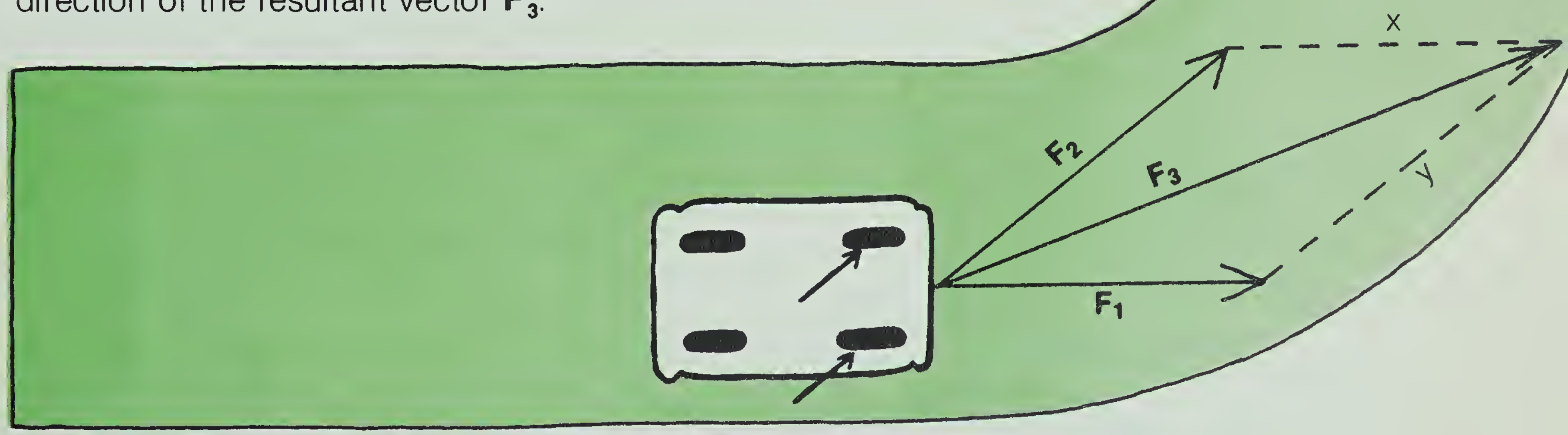


Figure 12–3

Now let's look at vectors representing forces. For example, suppose the force on a car, causing it to turn, is 2000 newtons. And suppose the forward force on the car, causing it to speed up, is 1500 newtons. The forces are shown in Figure 12–4. The scale used for the length of the vectors is 1 centimetre for 1000 newtons.

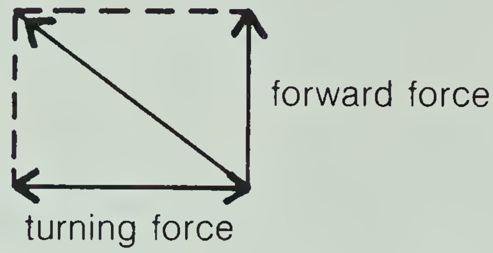


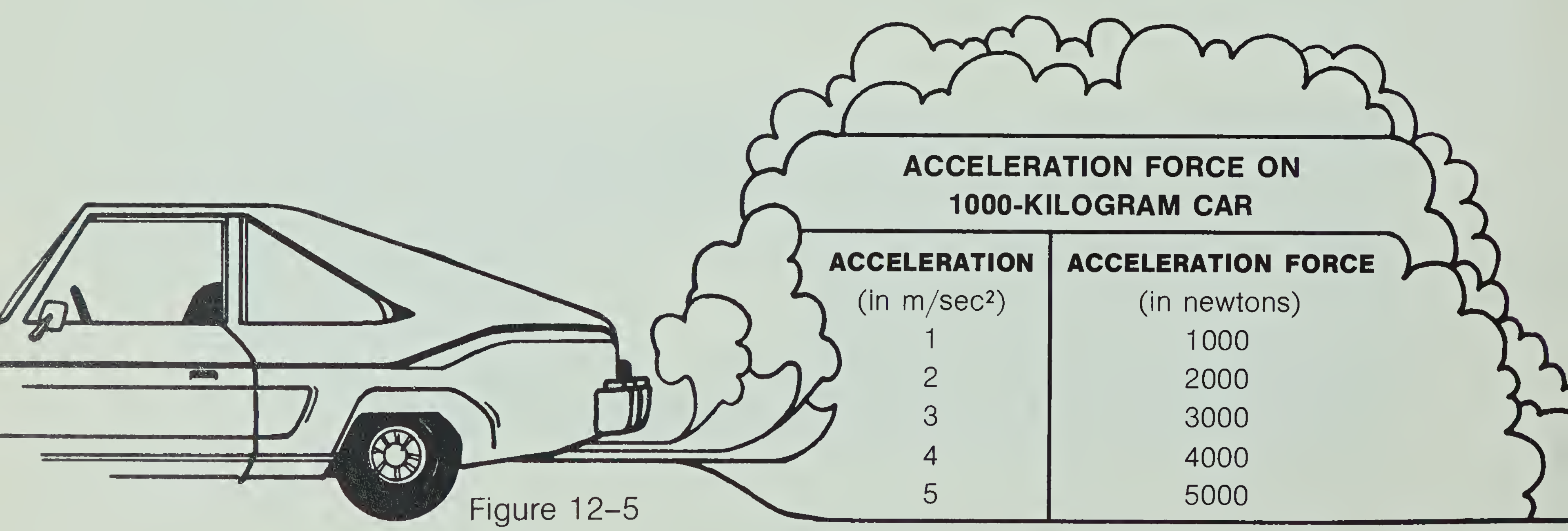
Figure 12–4

✓ 12–4. In Figure 12–4, how long is the resultant vector?

✓ 12–5. How many newtons of force are represented by the resultant vector?

★ **12–6. A racing car turns into a curve. The forward force speeding up the car is 1500 newtons. The force of friction turning the car is 750 newtons. What is the resultant force (in newtons) on the car?**

Now let's consider a car that is accelerated while turning into a curve. Suppose a 1000-kilogram (2200-pound) car is accelerated 1 metre per second in 1 second. What is the acceleration force? (Find it in Figure 12–5.) If the car is accelerated 5 metres per second in 1 second, what is the acceleration force? (The first answer is 1000 newtons; the second answer is 5000 newtons.)



ACCELERATION FORCE ON 1000-KILOGRAM CAR

ACCELERATION (in m/sec²)	**ACCELERATION FORCE** (in newtons)
1	1000
2	2000
3	3000
4	4000
5	5000

Figure 12–5

Once again consider the car turning into the curve. Suppose the curve has a 150-metre (165-yard) radius, and the car is traveling at 56 kilometres (34 miles) an hour. The force of friction needed to keep this car on the road can be found in Figure 12–6. It's 1613 newtons. Now suppose this car is accelerated 2 metres per second in 1 second. What is the resultant force on the car?

TURNING FORCE OF FRICTION ON CAR (IN NEWTONS)					
RADIUS OF CURVE (in metres)	VELOCITY (KILOMETRES PER HOUR)*				
	56	64	72	80	88
50	4840	6320	8000	9880	11,940
100	2420	3160	4000	4940	5970
150	1613	2106	2666	3293	3980
200	1210	1580	2000	2470	2985
250	968	1264	1600	1976	2388
300	806	1053	1333	1647	1990
350	691	903	1143	1411	1705
400	605	790	1000	1235	1492

* For a 1000-kg car

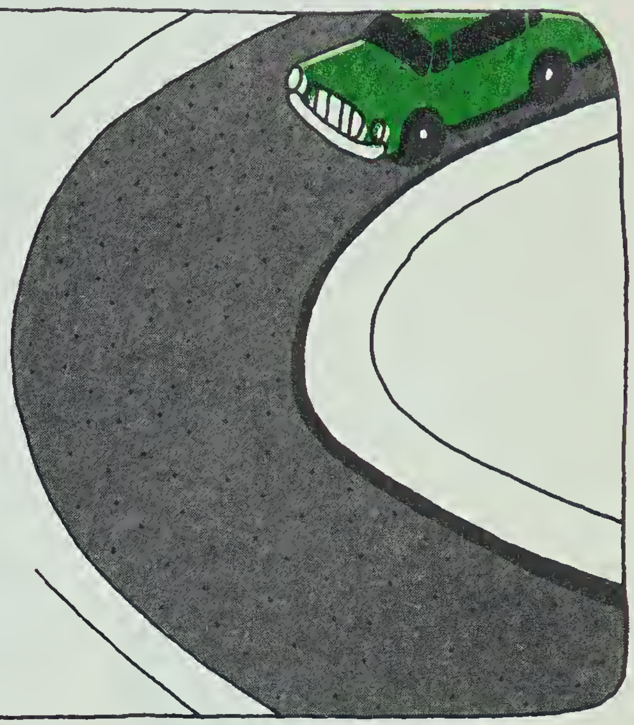


Figure 12–6

You can find the answer by using vectors. Let one vector represent the acceleration force of 2000 newtons (found in Figure 12–5). Let the other vector represent the friction force of 1613 newtons (found in Figure 12–6). The sum of the two vectors represents the resultant force on the car. See Figure 12–7.

1 centimetre represents 1000 newtons

Figure 12–7

The car pushes on the road's surface with a resultant force of about 2600 newtons. Will the car skid? Suppose the curve's surface is concrete. And suppose the surface is dry. Look at Figure 12–8 to find the maximum friction force for the car on dry concrete. It's 9000 newtons. The car will not skid.

If the resultant force is greater than the maximum friction force, the car will skid.

If the resultant force is less than the maximum friction force, the car will not skid.

MAXIMUM FRICTION FORCE IN NEWTONS FOR 1000-KILOGRAM CAR

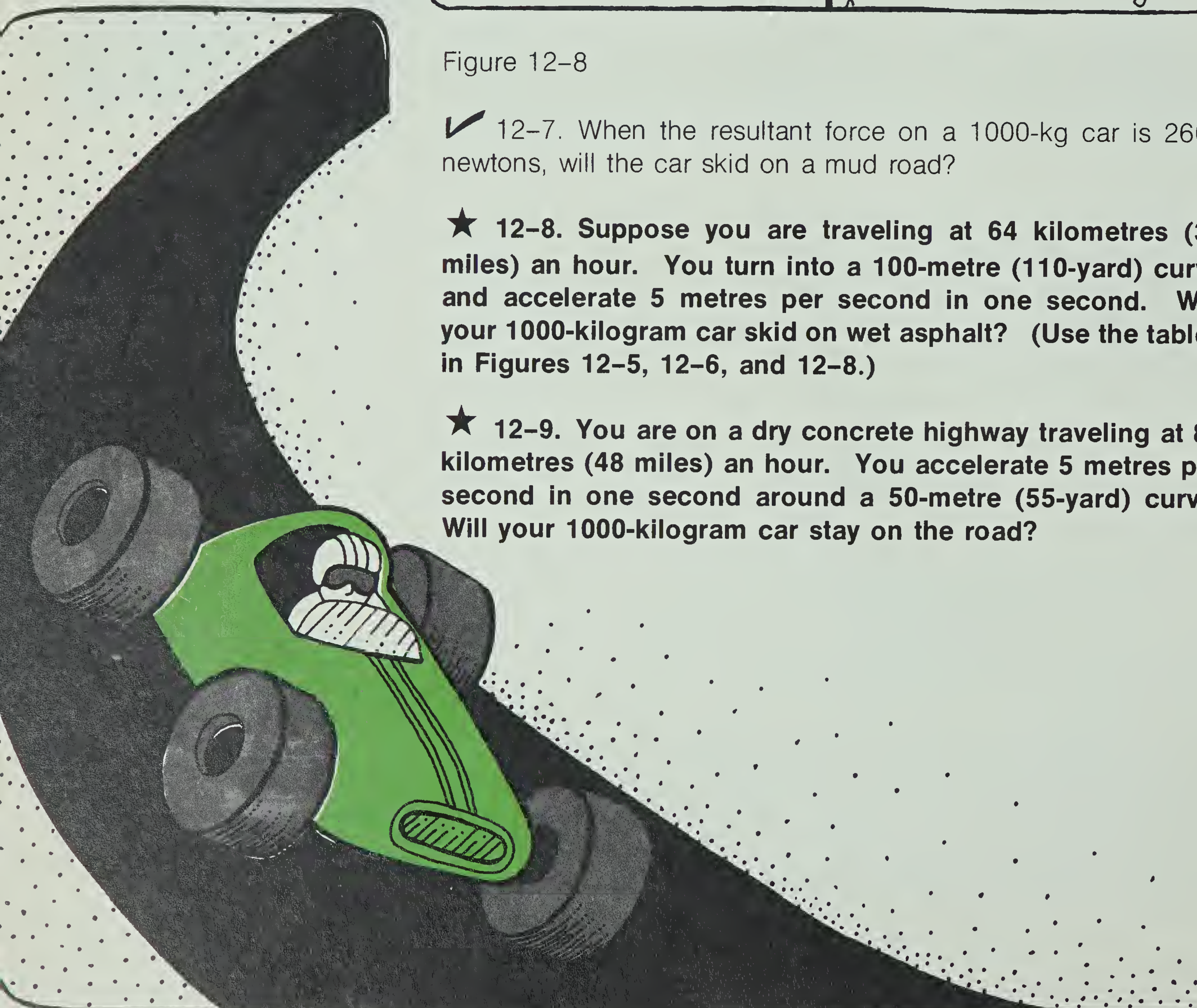
SURFACE	FORCE
Concrete (dry)	9000
Asphalt (dry)	8500
Asphalt (wet)	6500
Gravel	6500
Snow	4500
Mud	2500

Figure 12–8

✓ 12–7. When the resultant force on a 1000-kg car is 2600 newtons, will the car skid on a mud road?

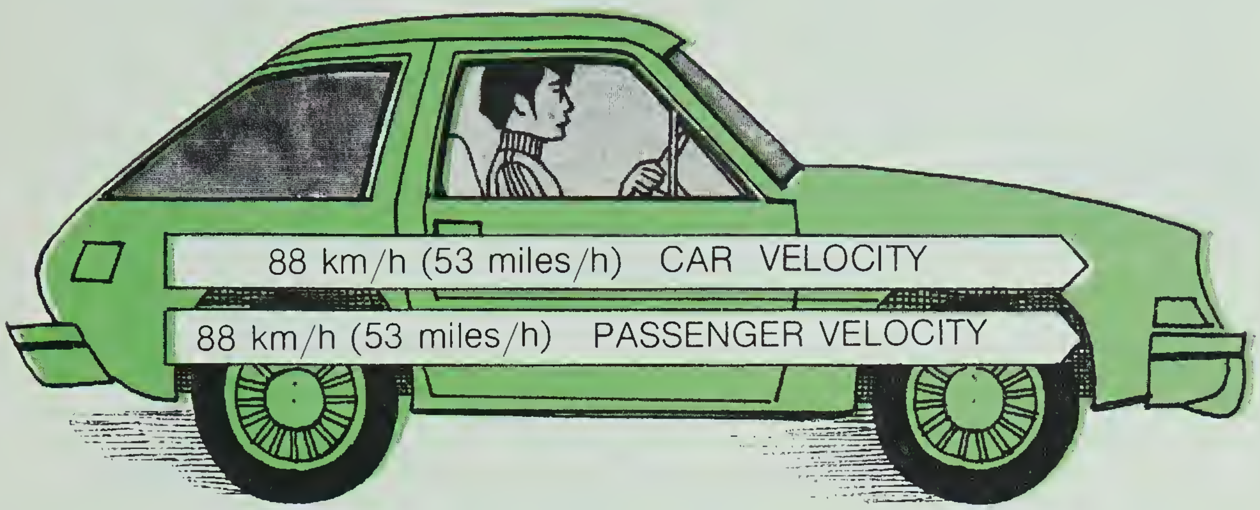
★ **12–8. Suppose you are traveling at 64 kilometres (38 miles) an hour. You turn into a 100-metre (110-yard) curve and accelerate 5 metres per second in one second. Will your 1000-kilogram car skid on wet asphalt? (Use the tables in Figures 12–5, 12–6, and 12–8.)**

★ **12–9. You are on a dry concrete highway traveling at 80 kilometres (48 miles) an hour. You accelerate 5 metres per second in one second around a 50-metre (55-yard) curve. Will your 1000-kilogram car stay on the road?**



Put On Your Seat Belt, Mr. Newton!

In Figure 13–1, the car and passenger are moving at the same velocity. That is, they are moving at the *same speed* and in the *same direction.*



Newton's first law: A body in motion remains in motion, moving at the same velocity, unless acted upon by an outside force.

Figure 13–1

Figure 13–2 shows what happens when the driver steps on the accelerator. There is a change in the car's velocity. The car speeds up. Look at the two *vectors* or arrows in Figure 13–2. Each vector represents the velocity of the car and passenger. The velocity vectors show the speed and direction of motion.

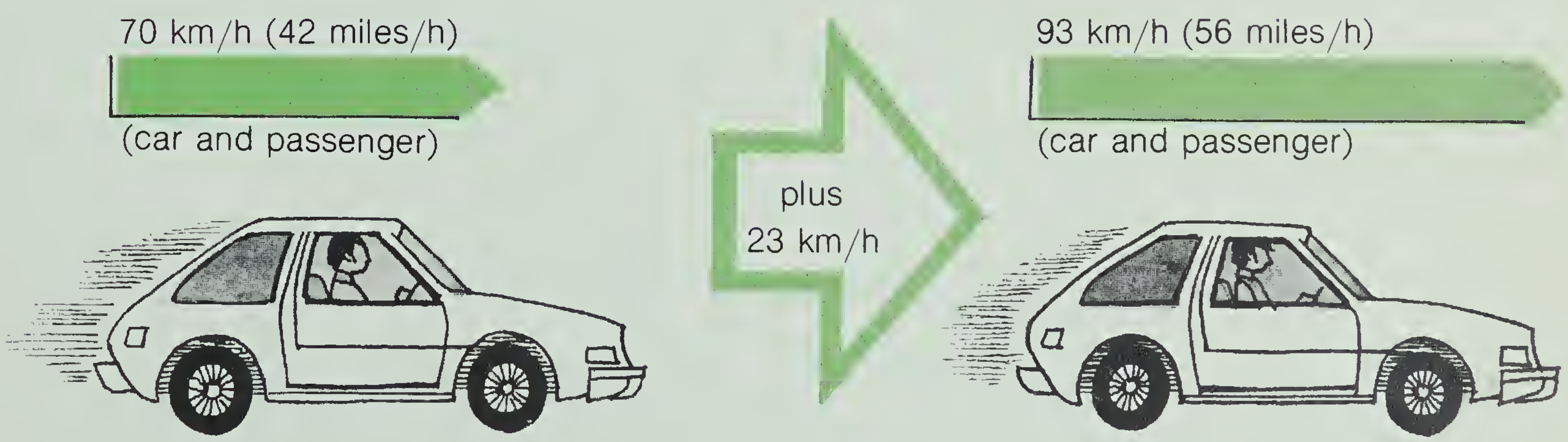


Figure 13–2

Newton's second law: The change of motion of a body is proportional to the outside force applied to that body.

✔ 13–1. In Figure 13–2, the vectors are of different lengths. What do the different lengths mean?

In Figure 13–3, the wall exerts a force on the car. The force is equal to that of the moving car, but in the opposite direction. There is a change in the car's velocity. The velocity becomes zero and the car stops. As the car stops, the dashboard, steering wheel, and fire wall exert a force on the passenger. The force is equal to that of the moving passenger, but in the opposite direction. There is a change in the passenger's velocity. It becomes zero and the passenger stops.

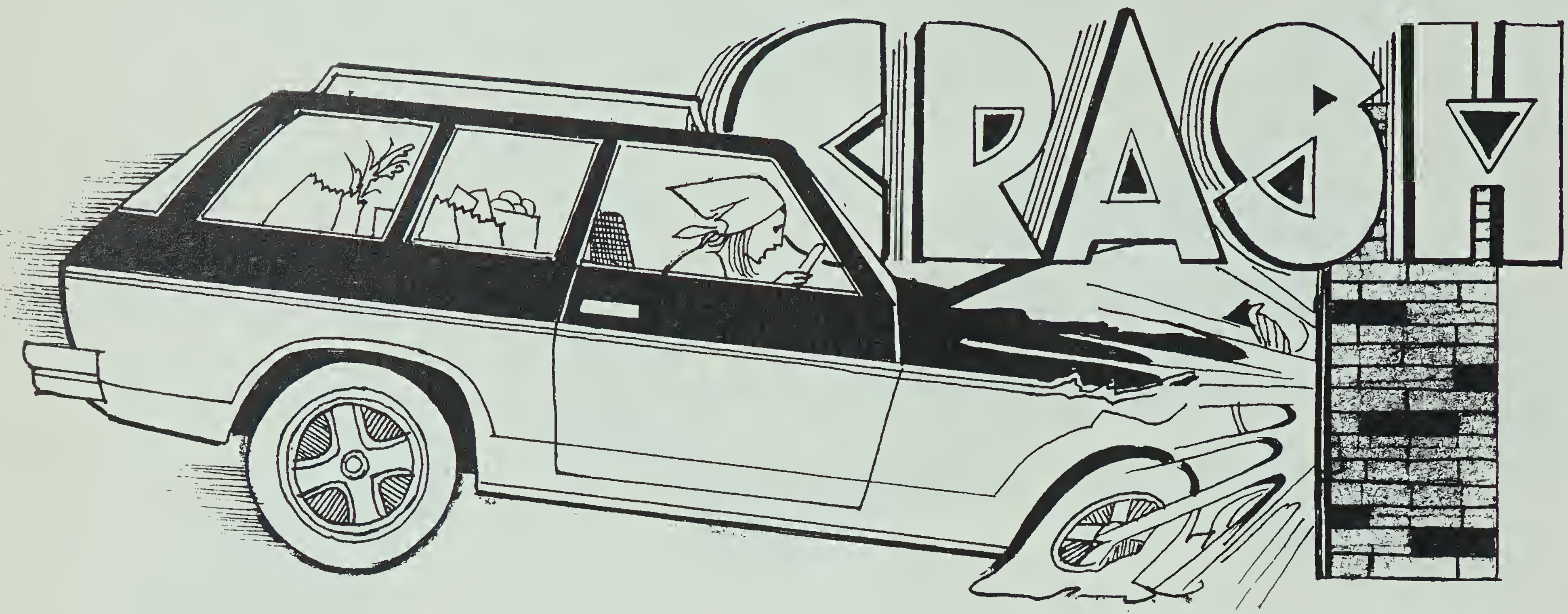


Figure 13–3

✔ 13–2. What is meant by a change in velocity? Give an example of a change in velocity.

Figures 13–2 and 13–3 show examples of changes in velocity. In Figure 13–2, the car gradually gains speed. In Figure 13–3, the car rapidly slows down.

Positive Acceleration is an increase in velocity or a "speeding up" in a certain amount of time.

Negative Acceleration is a decrease in velocity or a "slowing down" in a certain amount of time.

An outside force produced the changes in velocity shown in Figures 13–2 and 13–3. Newton studied outside forces such as these to find out how they related to velocity. He found that the amount of acceleration of an object (positive or negative change in velocity) depended on the force applied to the object and on the mass of the object. In fact, acceleration equals force divided by mass.

$$\text{Or force} = \text{mass} \times \text{acceleration}$$

$$f = m \times a$$

Suppose an 1100-kilogram car slows down 3 metres per second each second. How much force is acting on the car? Since the car is *slowing down,* the acceleration is negative: —3 metres per second per second.

$$f = m \times a$$

$$f = 1100 \text{ kg} \times (-3 \text{ m/s}^2)$$

$$f = -3300 \text{ kg}\cdot\text{m/s}^2$$

Notice that the unit of force is $\text{kg}\cdot\text{m/s}^2$. This unit is called a *newton.* One newton is the amount of force necessary to accelerate a one-kilogram mass one metre per second per second.

$$\frac{1 \text{ kg}\cdot\text{m/s}}{1 \text{ s}} \text{ or } 1 \text{ kg}\cdot\text{m/s}^2$$

So a force of 3300 newtons will accelerate a mass of 1100 kilograms 3 metres per second each second that it is applied. Since the car is being slowed down, the force has a negative sign (—3300 newtons).

✔ 13–3. How much force is needed to slow down an 1100-kilogram car 6 metres per second each second?

Suppose an 1100-kilogram car has an engine that exerts a force of 8800 newtons. In this case, the acceleration is 8 m/s^2. The car is speeding up. It has positive acceleration.

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$\text{or acceleration} = \frac{\text{force}}{\text{mass}}$$

$$a = \frac{f}{m}$$

$$= \frac{8800 \text{ newtons}}{1100 \text{ kg}} \text{ or } \frac{8800 \text{ kg}\cdot\text{m/s}^2}{1100 \text{ kg}}$$

$$= 8 \text{ m/s}^2$$

✔ 13–4. Suppose an 1100-kilogram car has an engine that is exerting a force of 1100 newtons. What is the acceleration of the car?

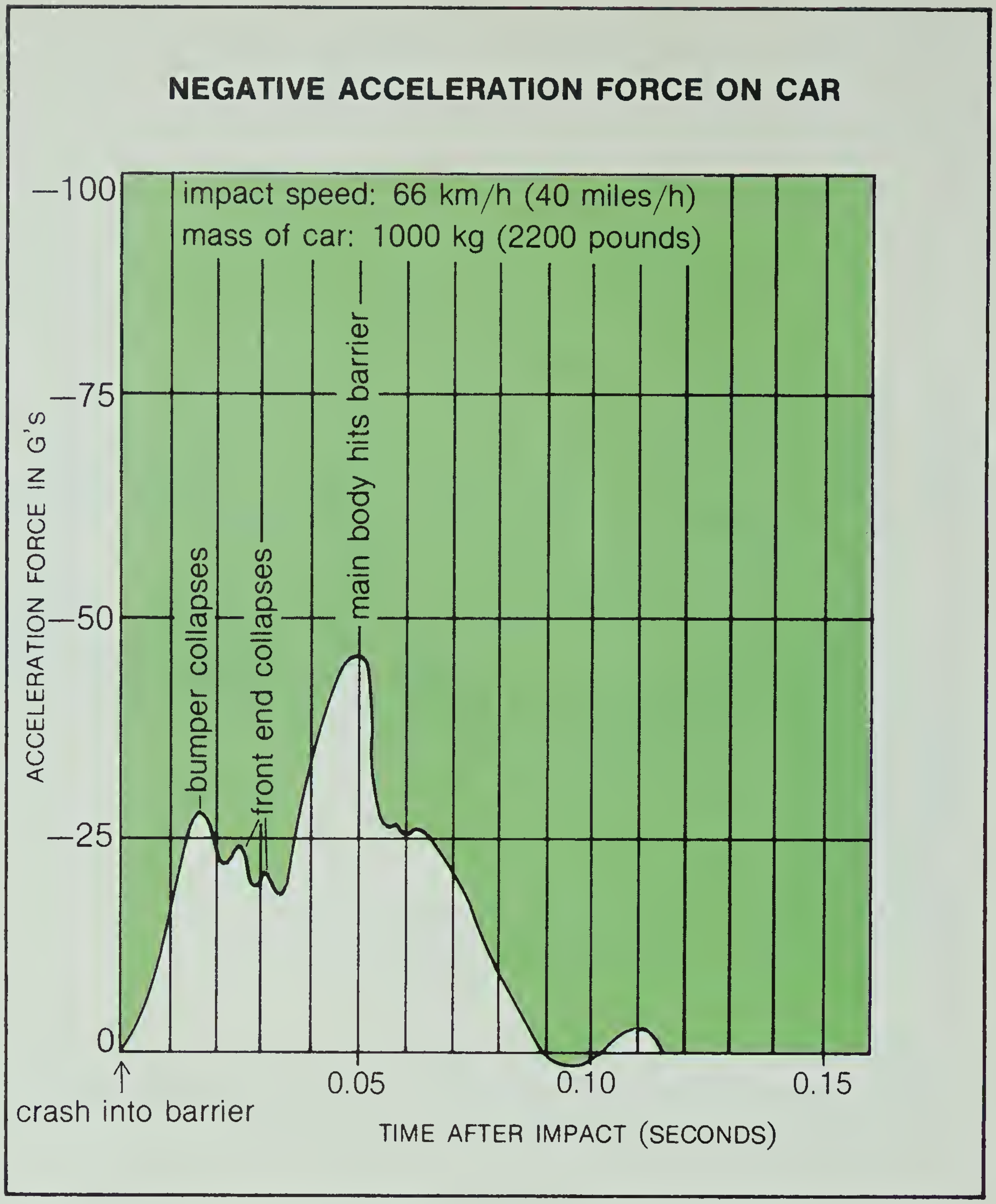


Figure 13–4

Crash experiments were run at the Road Research Laboratories in England. Both the dummies and the cars contained special instruments to measure the acceleration forces during the collisions. Results are shown in the graph of Figure 13–4. If you have trouble reading the graph, study *Resource Unit 2.*

In the graph, the vertical axis is labeled *Acceleration Force In G's.* A *G* is the constant acceleration force due to gravity. A force of 1*G* is equal to the weight of an object. A force of 25*G* is 25 times the force of gravity or 25 times the weight of the object.

✔ 13–5. Explain what is meant by a force of 50*G.*

Look at Figure 13–4. When the line in the curve rises, the acceleration force is increasing. This means that the car is slowing

down. It is important to remember that for this graph, the acceleration force is negative. The car is slowing down.

✓ 13–6. What is happening to the acceleration force when the line in the curve falls?

In his second law of motion, Newton said: The change of motion of a body is proportional to the outside force applied to the body. Look at Figure 13–4. The car slows down quickly when it hits the barrier. By the time the bumper collapses, the negative acceleration force on the car is about 25*G*. When the car's body hits the barrier, the car stops. The negative acceleration force is about 45*G*: 45 times the force due to gravity. Then the car rebounds. The acceleration force goes from 45*G* to 25*G*.

Once again look at Figure 13–4. Notice that it is about 0.02 second after the car hits the barrier that the bumper collapses. The car's velocity by this time has changed from 66 kilometres (40 miles) an hour to 48 kilometres (29 miles) an hour. How much force is needed to change the velocity of the car? Find the force in newtons and in *G*'s.

To find the force in newtons, use the equation:

$$F = ma$$

The mass *m* of the car is known. It is 1000 kilograms (2200 pounds). But the acceleration, *a*, must be found. When the car hits the barrier it is going 66 kilometres an hour. After 0.02 second, the car is going 48 kilometres an hour.

$$a = \frac{(66\ \text{km/h}) - (48\ \text{km/h})}{0.02\ \text{s}} \text{ or } \frac{18\ \text{km/h}}{0.02\ \text{s}}$$

Since the acceleration is negative,

$$a = -\frac{18\ \text{km/h}}{0.02\ \text{s}}.$$

But we have to express *a* in *metres per second per second*, not kilometres per hour per second. Why? Because one newton is the amount of force needed to accelerate a one-kilogram mass one metre per second in one second. In this case, the acceleration is:

$$a = \frac{-18\ \text{km/h}}{0.02\ \text{s}} \text{ or } \frac{-18000\ \text{m}/3600\ \text{s}}{0.02\ \text{s}} \text{ or } \frac{-5\ \text{m/s}}{0.02\ \text{s}}$$

Now that we know m and a we can find F.

$$F = ma$$

$$= (1000 \text{ kg}) \left(\frac{-5 \text{ m/s}}{0.02 \text{ s}}\right)$$

$$= \frac{-5000 \text{ kg}\cdot\text{m/s}}{0.02 \text{ s}}$$

(To simplify this, multiply the numerator and the denominator by 50.)

$$= \frac{-250{,}000 \text{ kg}\cdot\text{m/s}}{\text{s}} \text{ or } -250{,}000 \text{ newtons}$$

At 0.02 second after impact, the acceleration force is —250,000 newtons.

The negative sign means it is a negative acceleration force. Now express the size of this force (250,000 newtons) in *G*'s. First find the weight of the car in newtons.

weight (force due to gravity) = mass × acceleration due to gravity

The car's mass is 1000 kilograms. The acceleration due to gravity is about 10 metres per second per second.

$$\text{weight} = (1000 \text{ kg}) \left(\frac{10 \text{ m/s}}{\text{s}}\right)$$

$$= \frac{10{,}000 \text{ kg}\cdot\text{m/s}}{\text{s}}$$

or 10,000 newtons

The weight of the car is 10,000 newtons or 1*G*. Now divide the acceleration force, 250,000 newtons, by the weight of the car, 10,000 newtons.

$$\frac{250{,}000 \text{ newtons}}{10{,}000 \text{ newtons}} = 25G\text{'s}$$

Look at Figure 13–4. The time that passed between the car's front end collapsing and the main body of the car hitting the barrier is about 0.03 second. The car's velocity changes from 40 kilometres (24 miles) an hour to 0 kilometres (0 miles) an hour.

✓ 13–7. How much force is needed to change the velocity of the car? Find the force in newtons and in G's.

While all this is going on with the car, what's happening to the passenger? The instruments attached to the dummy show us what forces act on the passenger. The graph of these forces is shown in Figure 13–5. In this test sequence, the dummy is unrestrained. It is not wearing a seat belt.

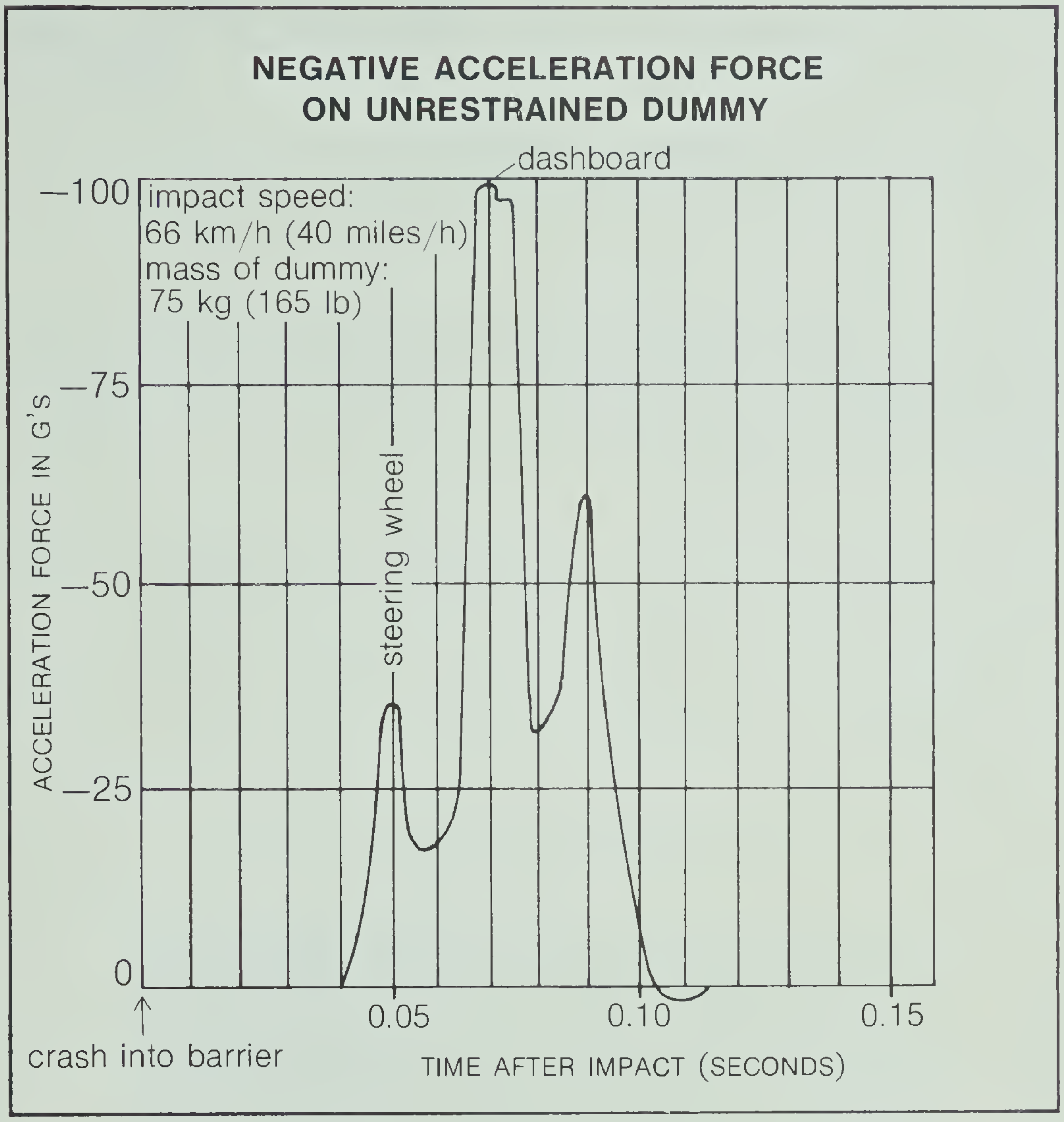
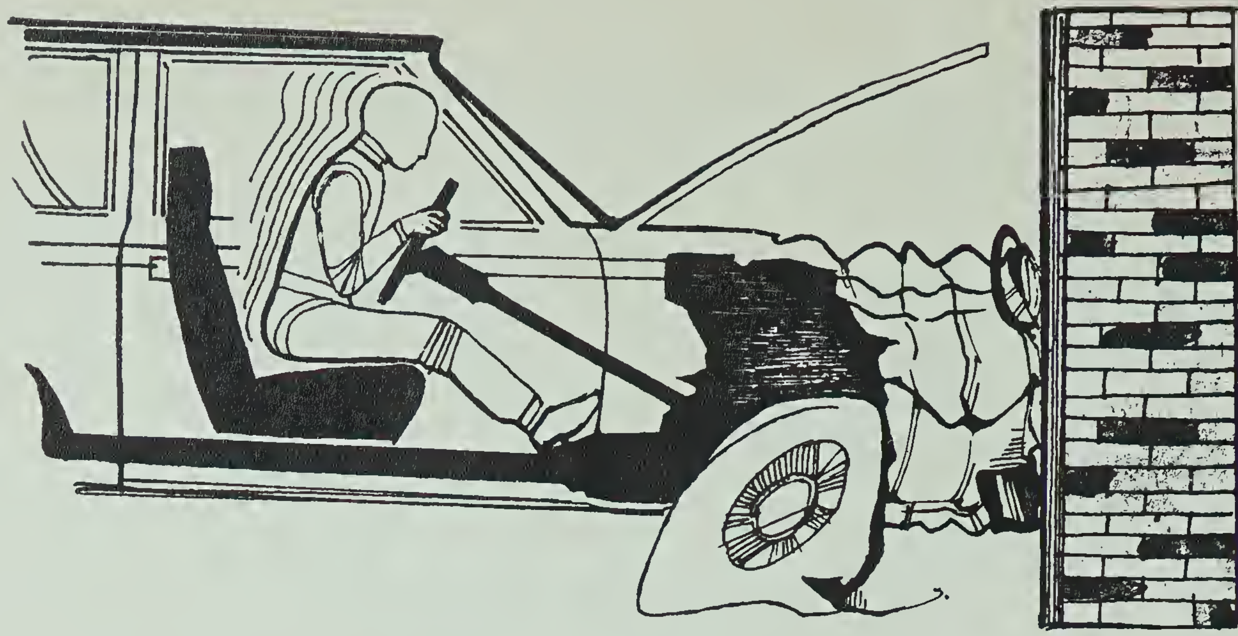


Figure 13–5

✓ 13–8. Look at Figure 13–5. How much time passes after the crash before the dummy begins to slow down?

✓ 13–9. What is the greatest amount of force that acts on the dummy? Express the force in newtons and in *G*'s.

At 0.03 second after the crash, the car is stopping. But the dummy continues to move toward the steering wheel. At this time there is no outside force acting on the dummy.



At 0.05 second after the crash, the dummy is briefly slowed down by the steering wheel. This is shown in the graph in Figure 13–5.

★ **13–10. When the dummy hits the dashboard, the negative acceleration force is 100*G*'s. The mass of the dummy is 75 kilograms (165 pounds). What is the negative acceleration force in newtons?**

✔ 13–11. At about 0.09 second after impact, there is another peak in the curve. What do you think caused this peak?

Further experiments provided data for a dummy wearing a seat belt. The graph of these data is shown in Figure 13–6.

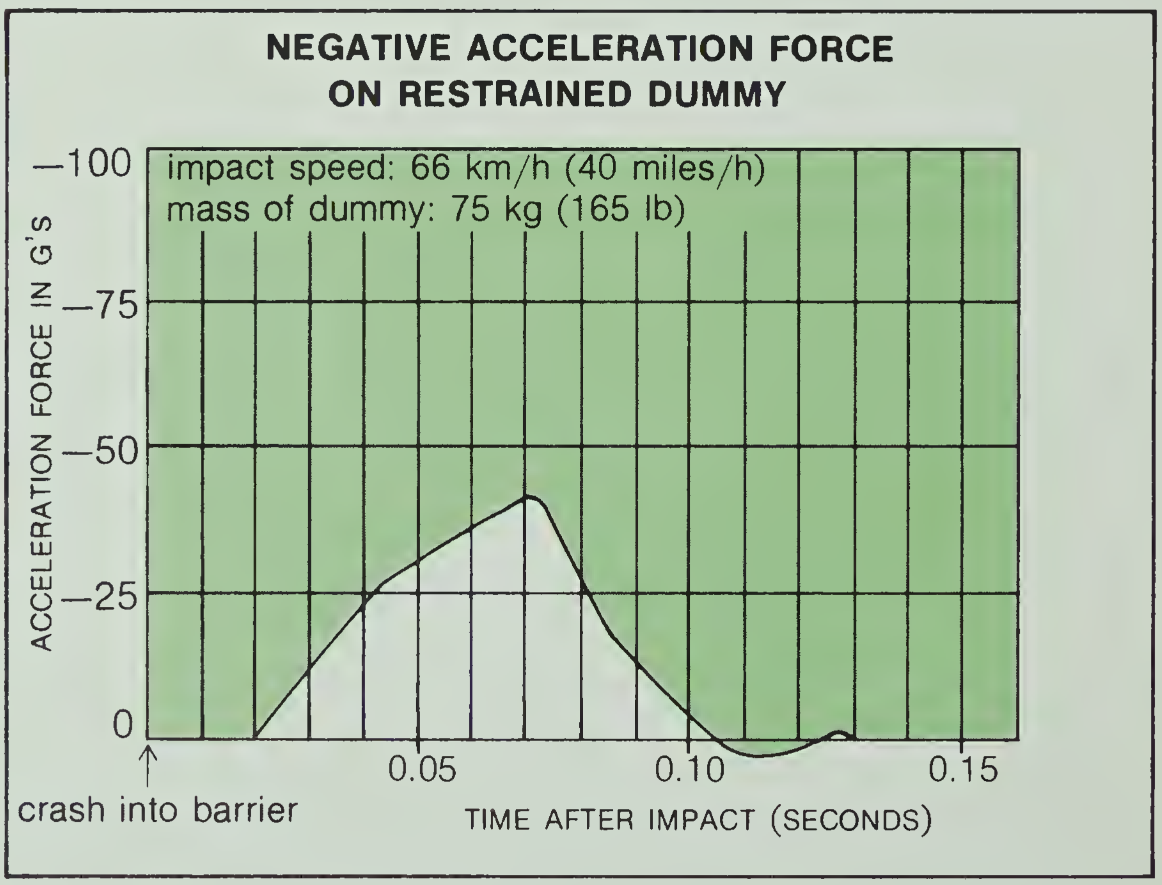


Figure 13–6

✔ 13-12. Look at Figure 13-6. How much time passes after the crash before the dummy begins to slow down?

★ **13-13. It took about 0.05 second for the dummy to go from 66 kilometres (40 miles) an hour to 0 kilometres (0 miles) an hour. What is the negative acceleration force in newtons? In *G*'s?**

Immediately after the crash, the car slows down. But the dummy continues to move 66 kilometres an hour. At 0.02 second after the crash, the dummy starts to strain against the seat belt. The negative acceleration begins to act: the belt begins slowing down the dummy.

At 0.07 second after the crash, the largest negative acceleration force acts on the dummy.

In less than 0.12 second after impact, the car has stopped moving. But the dummy continues to move. The seat belt has stretched and continues to pull back on the dummy. Finally, at 0.13 second after impact, the dummy is back in the seat and has stopped moving. This is 0.01 second after the car has stopped moving.

Figure 13-7 shows two graphs that you've been studying. It shows the negative acceleration force on the unbelted dummy and on the belted dummy. Notice the smooth curve for the belted dummy. It does not have peaks like the curve for the unbelted dummy.

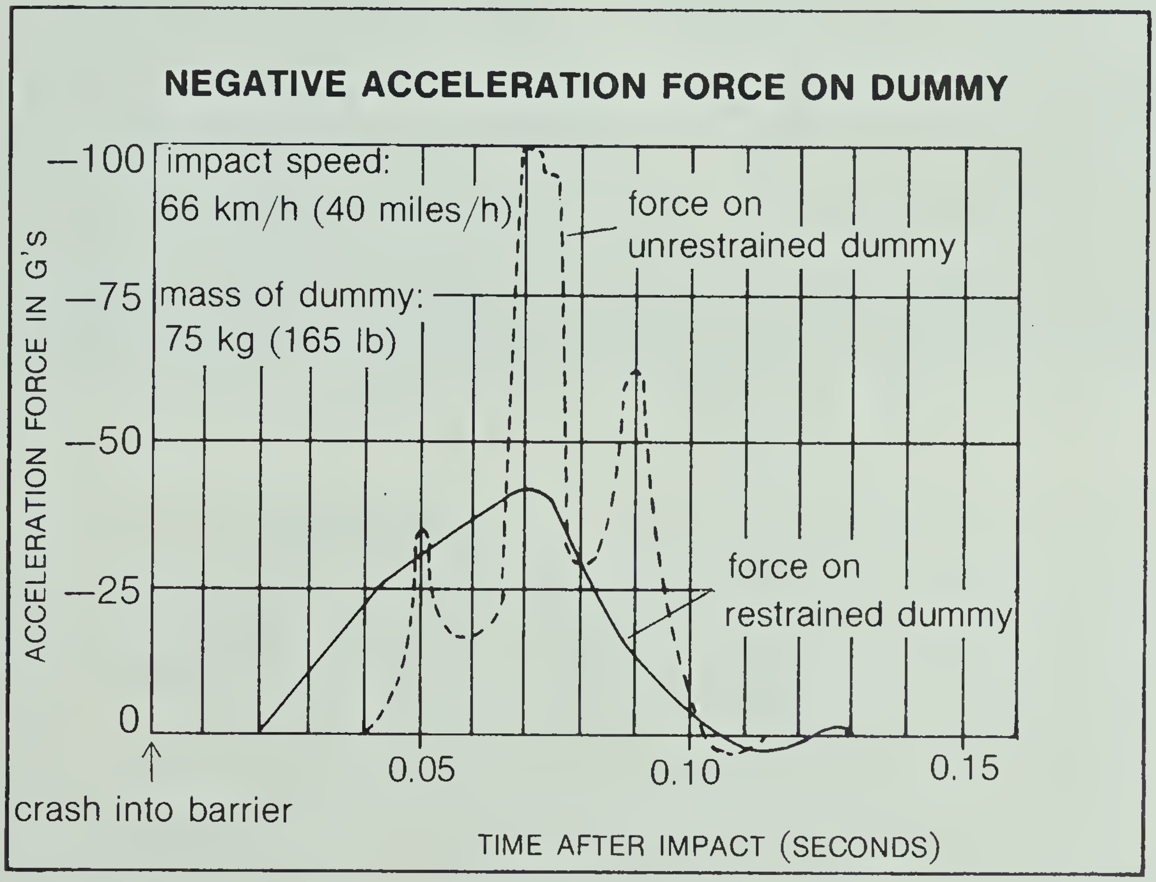


Figure 13-7

★ **13–14. Look at Figure 13–7. Why does the curve tend to smooth out when the dummy is restrained?**

A seat belt distributes the negative acceleration force over your body. This prevents the force from being concentrated on one place: like your head if it hits the dashboard. A seat belt also distributes the acceleration force over a greater period of time. The acceleration force on the belted dummy lasted about 0.11 second. The force on the unbelted dummy lasted about 0.07 second. So with a seat belt, the negative acceleration rate is slower, there is less peak force on your body, and your chances of serious injury are less.

Excursion

Activity 14 Planning

Activity 15 Page 68
Experts Speak Out

What has been done during the past ten years to make cars safer? What should still be done? Why haven't we done more? Listen to the viewpoints of three experts as they discuss these and other questions. It's your job to decide which arguments are fact and which are opinion.

Activity 16 Page 72
On-the-Road Safety Features

What safety features protect you from crashing into bridges, from going off the road into deep ditches, and from being crushed by sign posts? When you finish this excursion you'll know why highways are safer now than they were in the past.

Activity 15

Experts Speak Out

Experts often have as many opinions as facts. That's why it's important to listen carefully to what they say. The listener must determine which comments are facts and which are opinions.

✓ 15–1. Identify each of the following phrases as fact or opinion. Remember, a fact can be supported by evidence or checked for accuracy.

a. In an editorial of *The New York Times* of May 13, 1975, reasons were given . . .
b. In my view, they did not make changes fast enough to . . .
c. Most people know that . . .

It's more difficult to tell fact from opinion when you're *listening* to statements rather than reading them. In this activity, you will listen to two experts on packaging passengers. Each of the experts sees the subject from a different viewpoint.

Now listen to what these people have to say. Find the tape for *Packaging Passengers* and listen to the side for Activity 15. First you may want to read Questions 15–2, 15–3, and 15–4. But don't answer the questions until you've heard the tape.

15–2. Match each phrase, *a* through *f,* to one of the six illustrations in Figure 15–1.

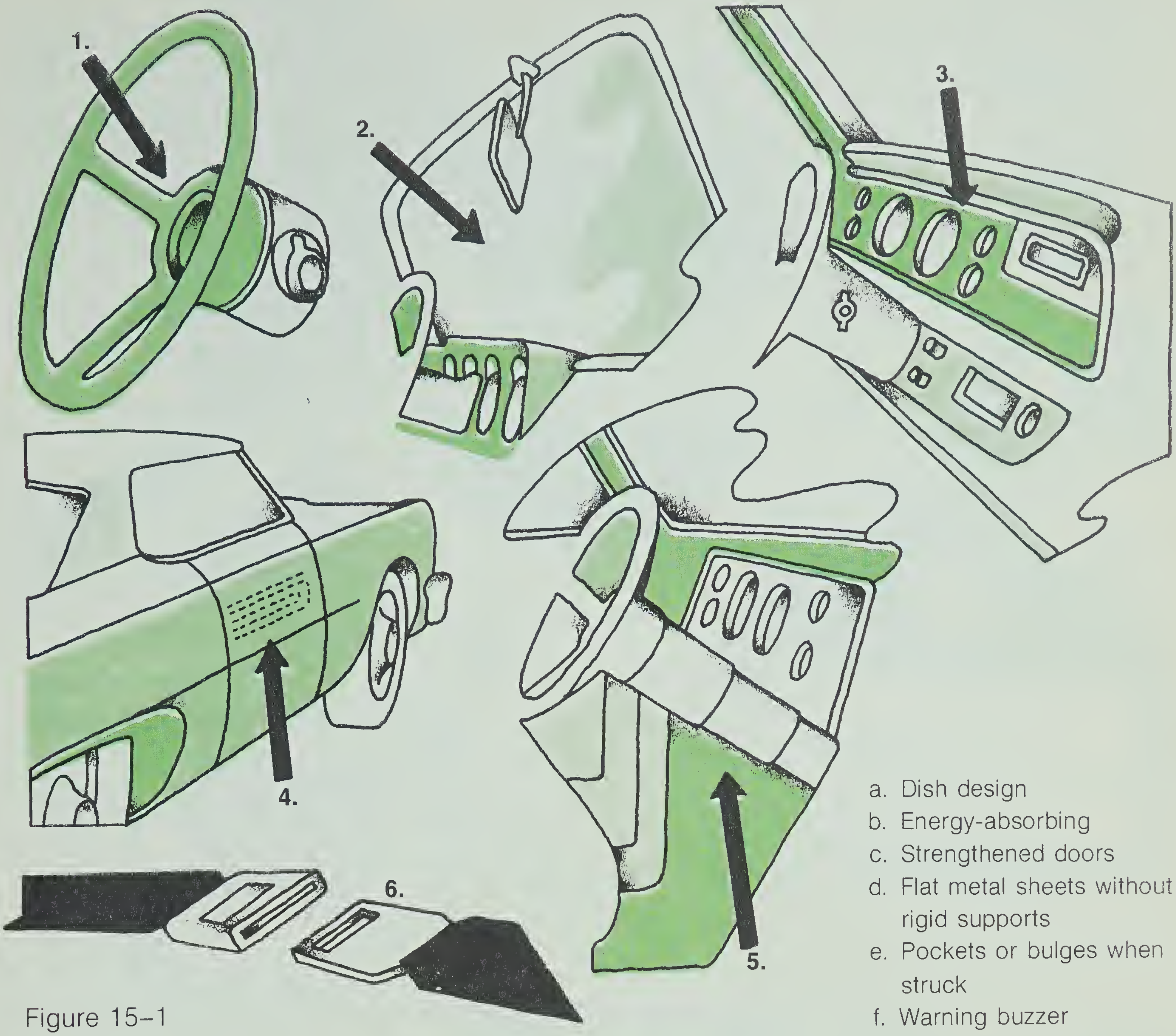


Figure 15–1

a. Dish design
b. Energy-absorbing
c. Strengthened doors
d. Flat metal sheets without rigid supports
e. Pockets or bulges when struck
f. Warning buzzer

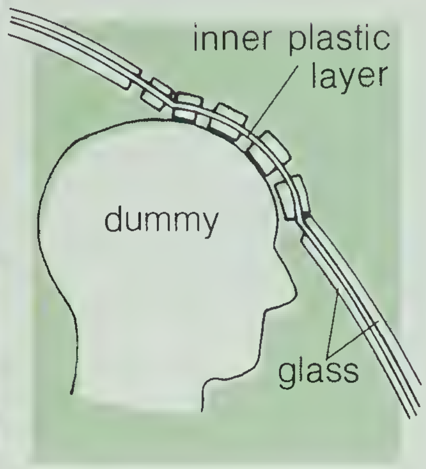
We often create our own problems. First we invented the automobile. Then we built smoother highways and faster cars. With these technological advances came an increasing number of deaths from car crashes. Now we are trying to reduce the number of deaths by using legal, technological, and other means.

15–3. In Figure 15–2 (page 70), *a* through *f* show some methods used to reduce highway deaths. Write the letters *a* to *f* in your notebook. Then identify each method as being legal (*L*), technological (*T*), or neither legal nor technological (*N*).

Figure 15-2

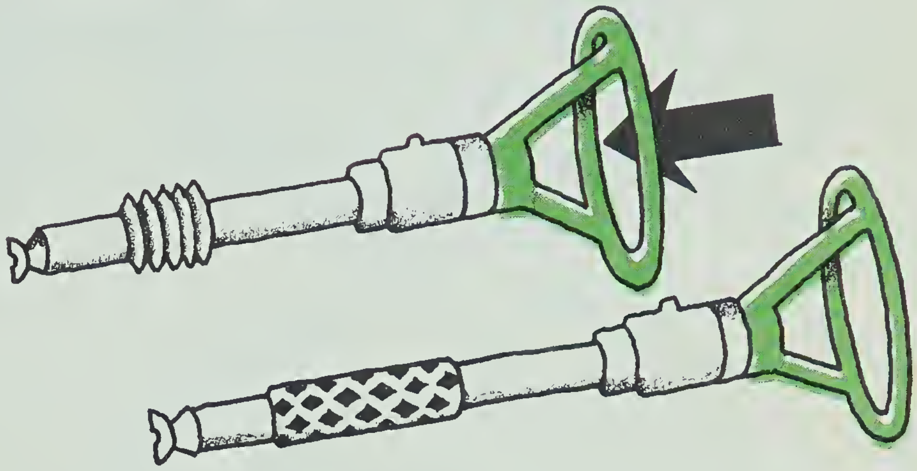
✓ 15-4. In the tape, one of the speakers claims that the automobile companies are giving the public what it wants. Is the speaker making a statement of fact or a statement of opinion?

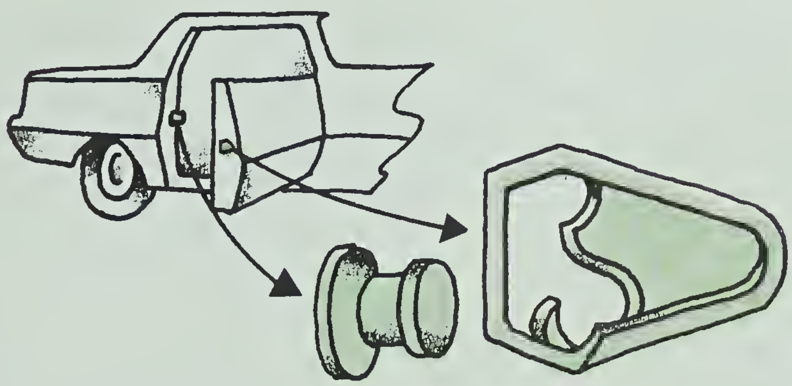
As you know, there have been many technological advances in the design of cars. Some are illustrated below.



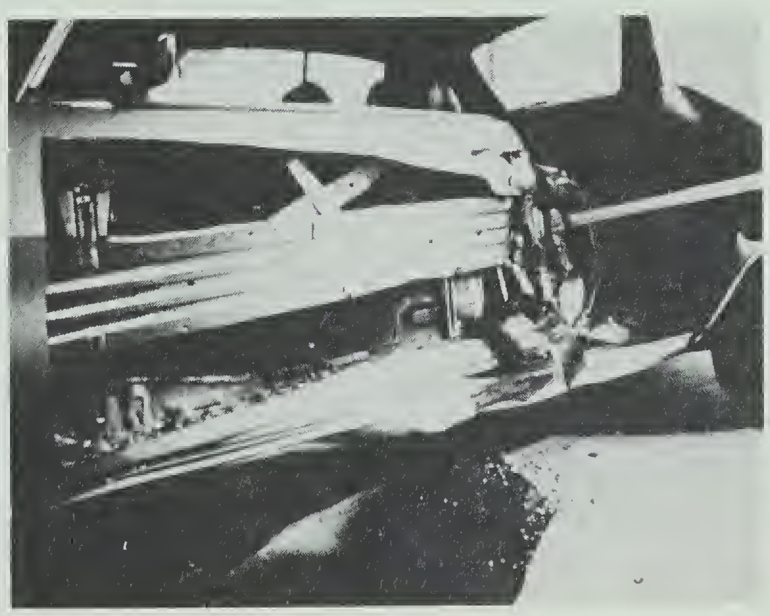
Safer windshields. The secret to improved windshields is lamination. A layer of plastic is sandwiched between two layers of glass. On impact, the windshield bulges. It does not shatter. Notice how the windshield forms a pocket over the dummy's head. This spreads the deceleration force over a large area of the head.

Energy-absorbing steering column. Before 1967, the impact of drivers against rigid steering wheels caused many deaths. Since then, energy-absorbing steering columns have been introduced. When a driver crashes into the wheel, the steering column collapses. This reduces the impact on the driver.





Anti-burst latches. Twenty years ago, ten percent of the people in accidents were ejected (thrown out) from the car. Today, with new and stronger latches, doors fly open less often. Now less than three percent of the people in car crashes are ejected from the car.



Door guard beams. Strong straps of steel are welded inside the car doors to strengthen them. This reduces the amount of door crushing during side collisions. The door can withstand side collisions up to 50 kilometers (30 miles) an hour.

★ **15–5. Describe five changes in automobile design that have made cars safer.**

✓ 15–6. Explain why you would accept or reject this statement: To solve problems created by technology we must use public opinion, advertising, and legal methods, not technology.

★ **15–7. Is the following statement a fact or an opinion? Why do you think so?**
"The auto industry has waited too long to install safety devices."

On-The-Road Safety Features

Today's highways have many safety features. Some are shown in Figure 16–1. How many can you find in the drawing?

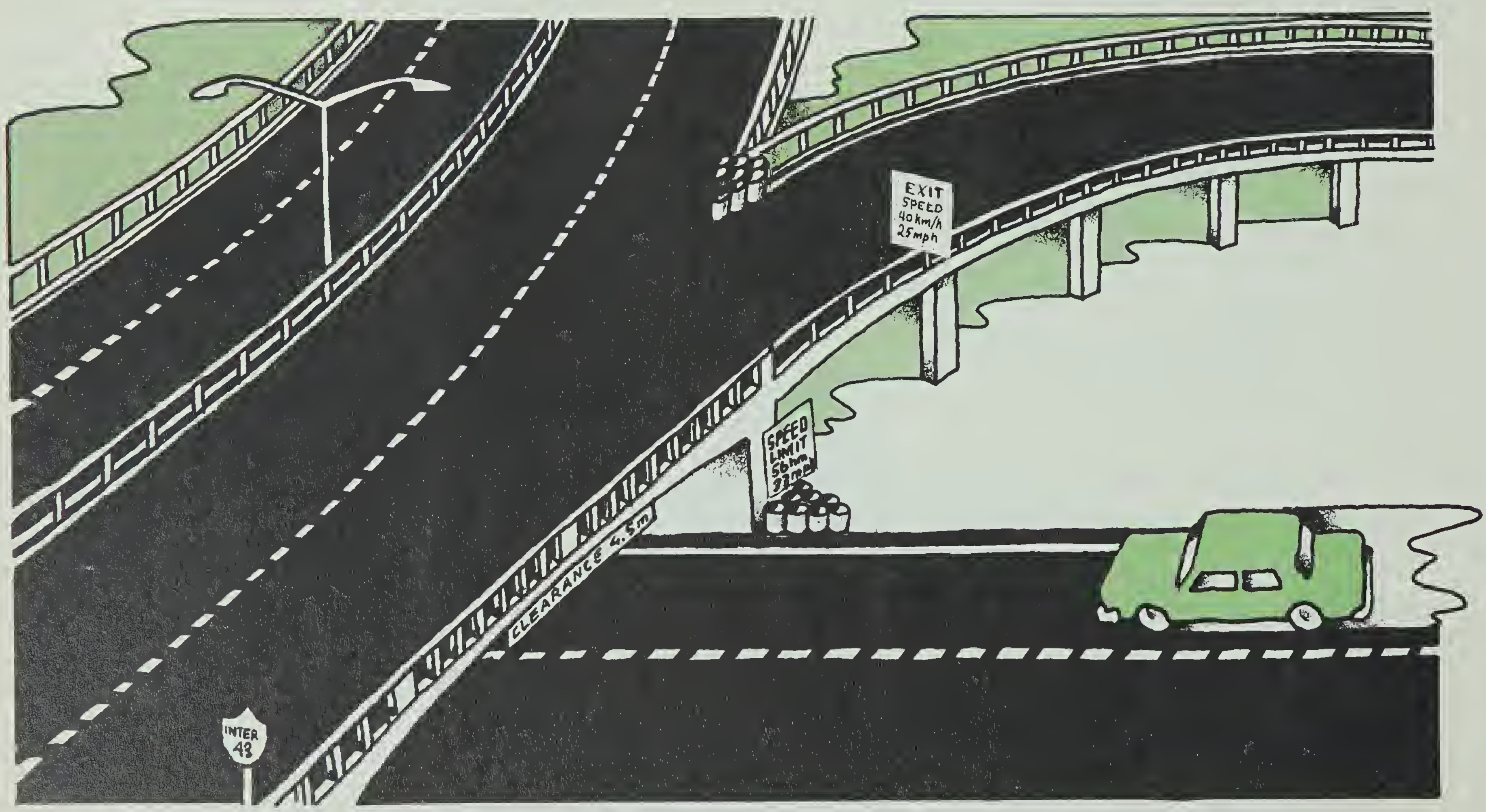


Figure 16–1

Three main safety features in Figure 16–1 are *barrels of life* (filled with sand), *guard rails,* and *break-away poles.* Let's consider each of these separately.

BARRELS OF LIFE

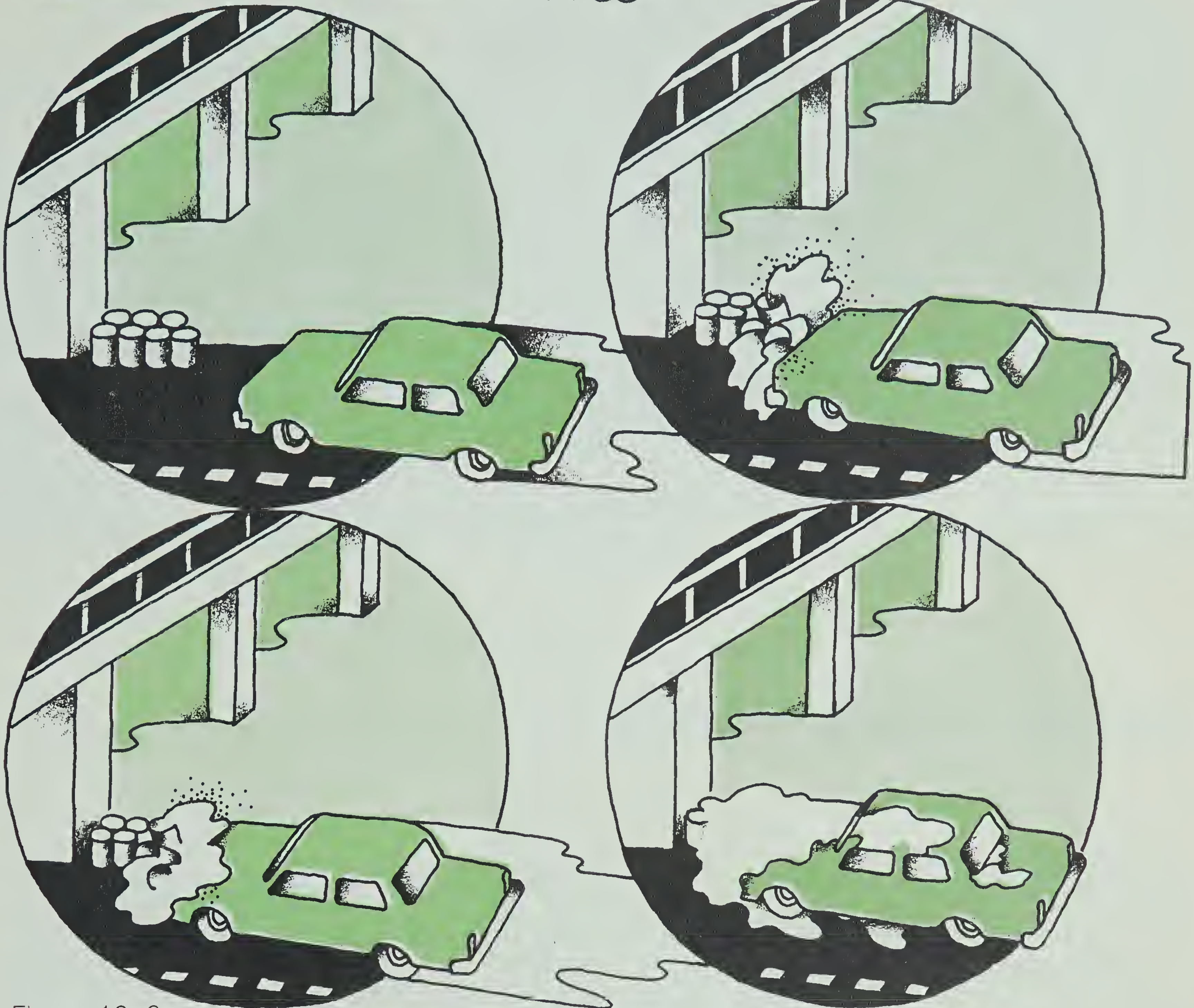


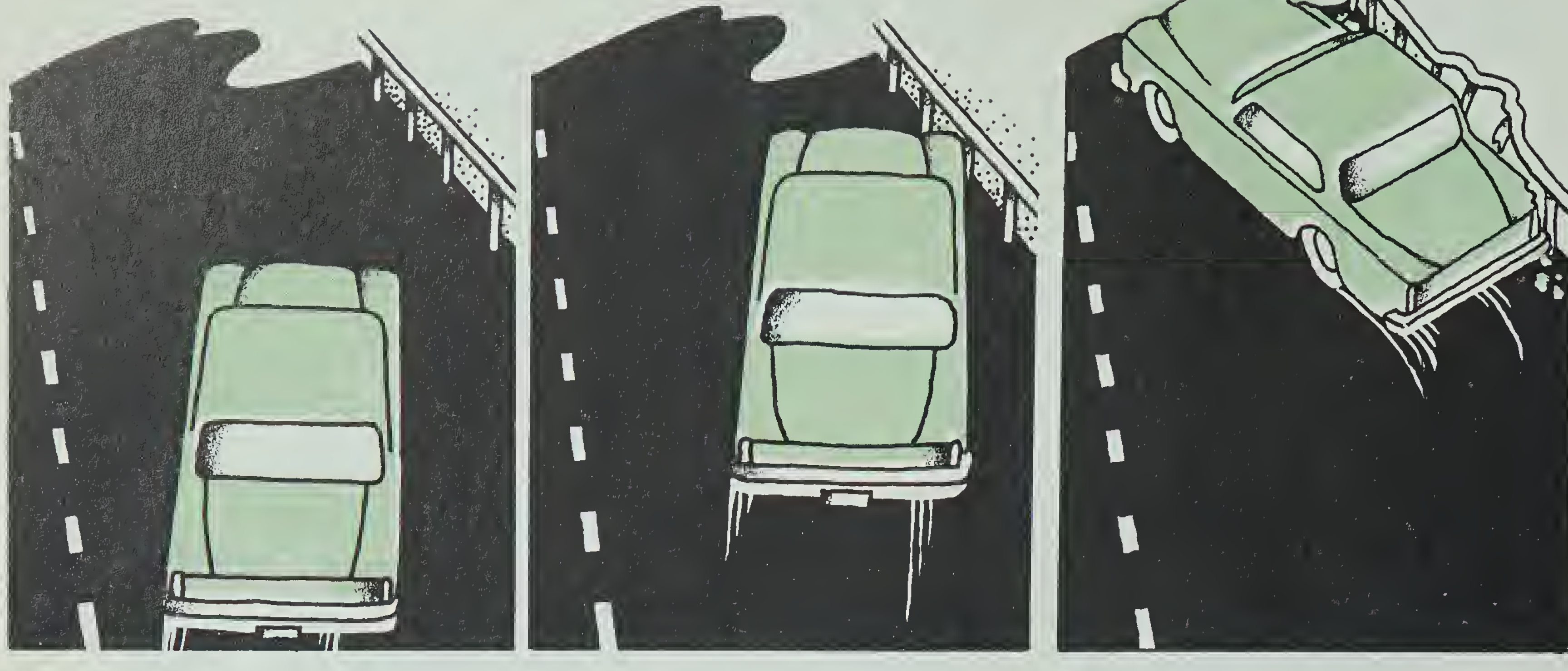
Figure 16–2

✔ 16–1. Describe what the car would have looked like if the barrels of life were not there.

✔ 16–2. Describe how the barrels of life may save a passenger's life.

✔ 16–3. The energy of motion of the car is transferred. Why is it better to transfer this energy to the barrels rather than to the bridge?

GUARDRAIL



16-4. Why are guardrails placed along the highway next to ditches or steep drops?

16-5. Why are guardrails placed along the middle strip of a divided highway?

BREAK-AWAY POLES

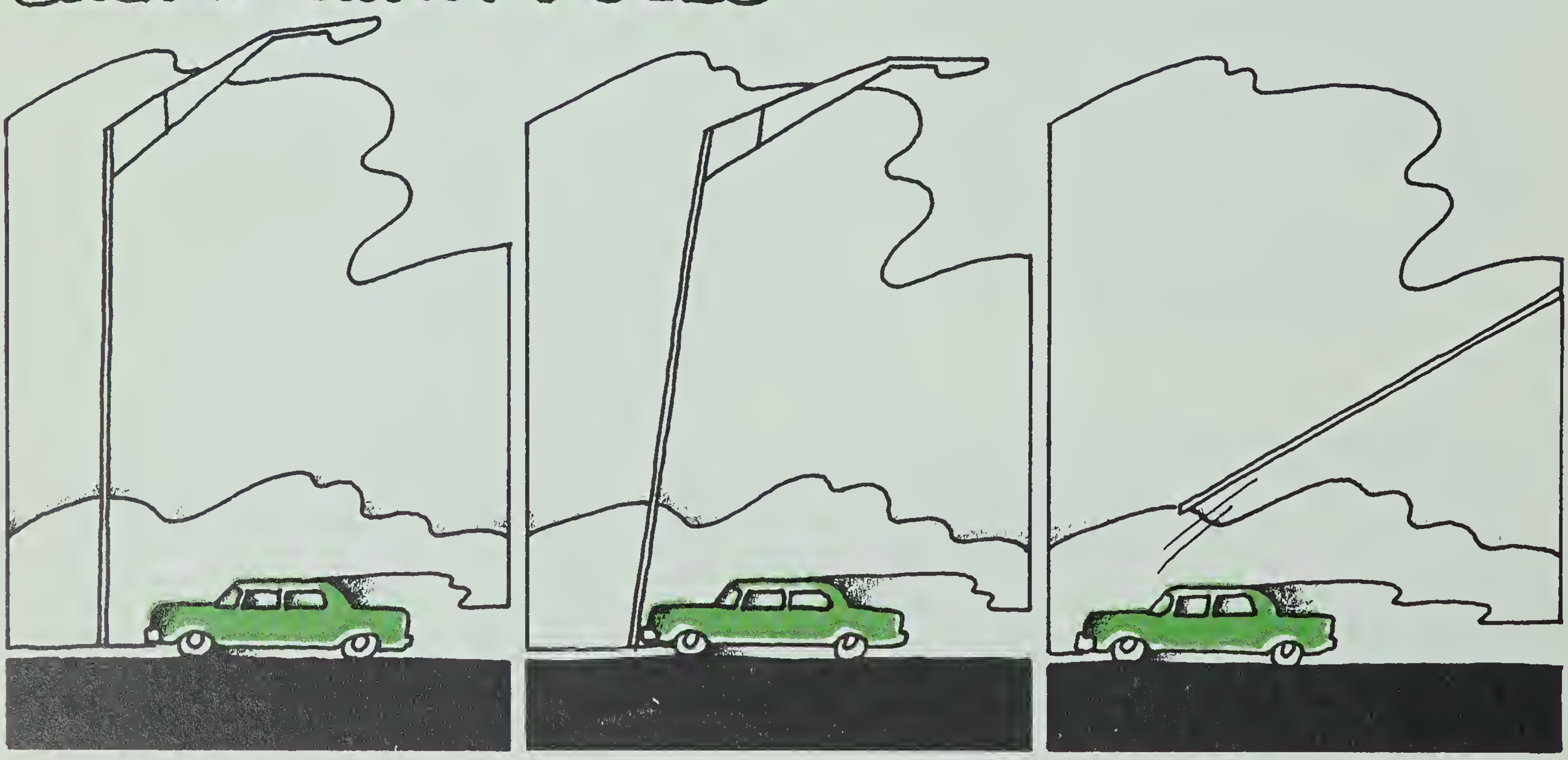


Figure 16-4

✔ 16–6. What might have happened to the car if the pole was not a break-away pole?

There are other less obvious safety features along the road. Some are shown in Figure 16–5.

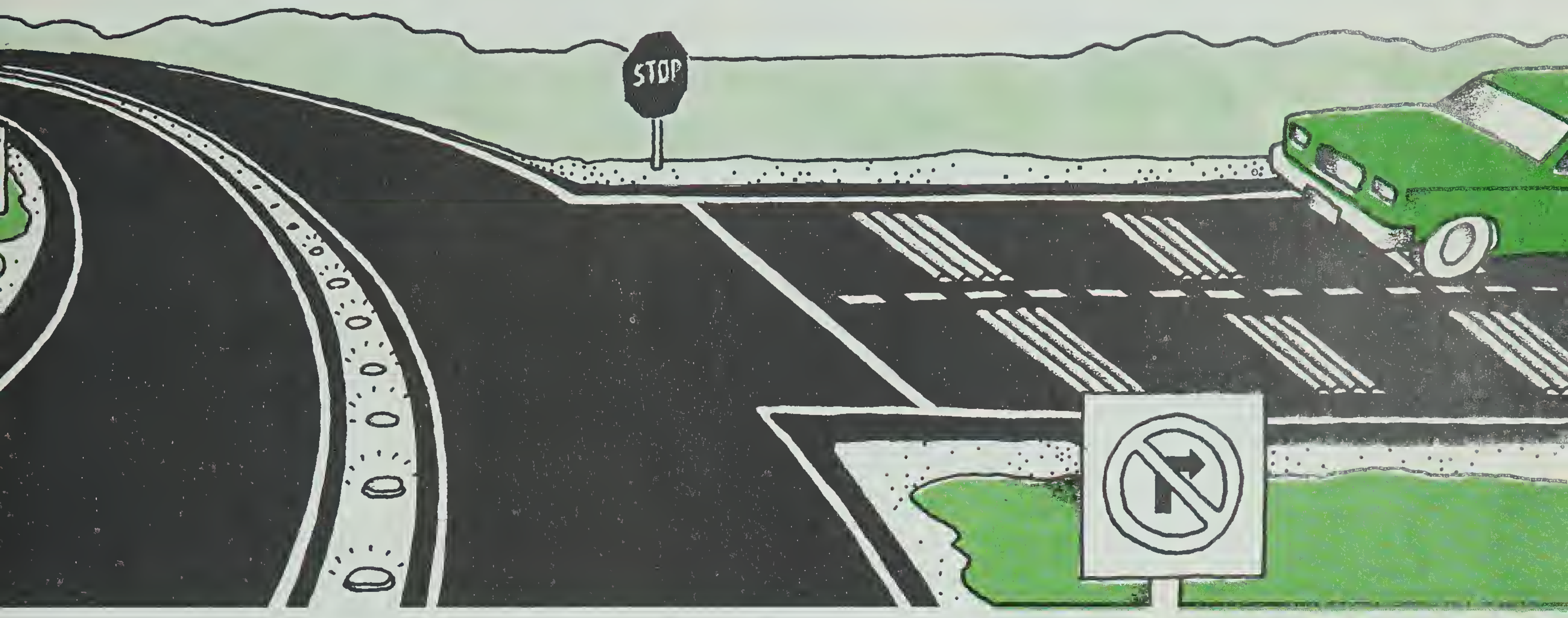


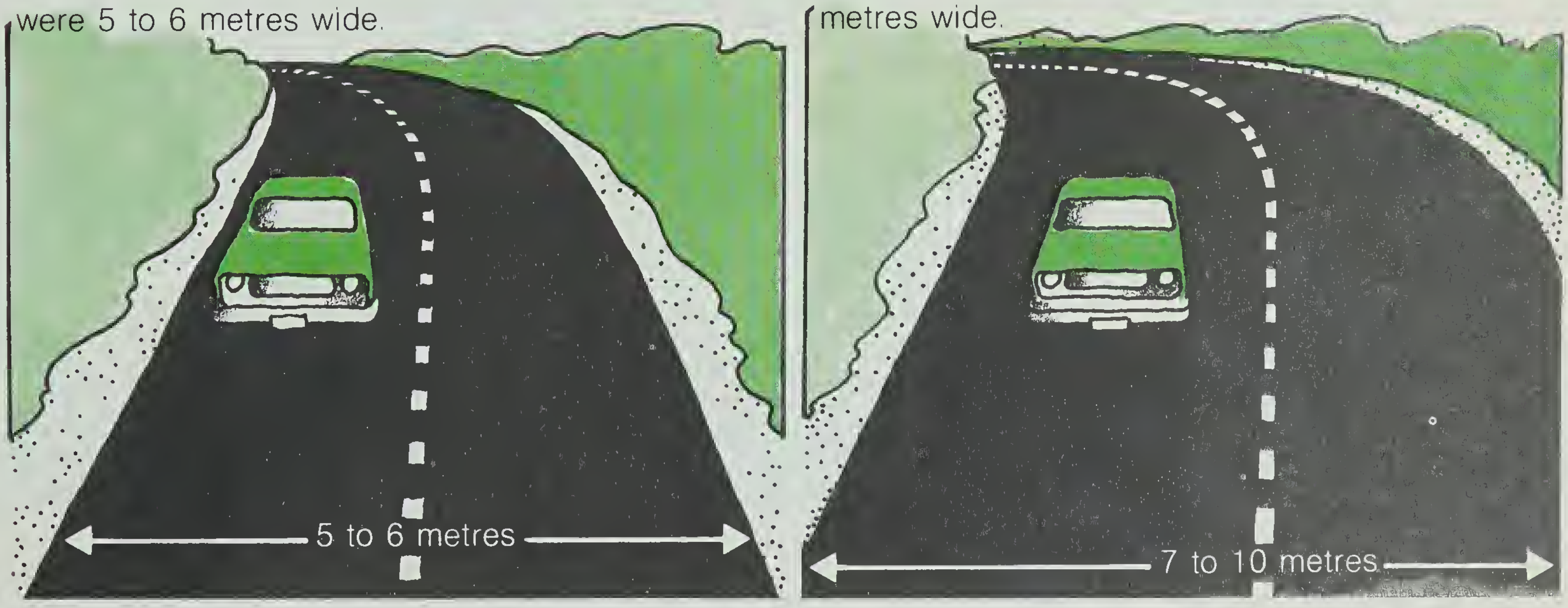
Figure 16–5

★ **16–7. List six safety features shown in Figure 16–5.**

★ **16–8. Look at your answers for Question 16–7. Choose one safety feature and explain how it saves lives.**

In the 1950's, most two-lane highways were 5 to 6 metres wide.

Now two-lane highways are 7 to 10 metres wide.



✔ 16–9. Describe some ways that widening a highway may save a passenger's life.

Human error is one of the primary causes of traffic accidents. Some of the most common errors are shown in Figure 16–6.

Figure 16–6

★ 16–10. Look at Figures 16–1 and 16–5. Choose one safety feature and explain how it will prevent injury due to human error.

HIJK 0854
PRINTED IN THE UNITED STATES OF AMERICA

The ISIS Project is an intricate effort involving man
following individuals have made significant contribu

ISIS Permanent Staff

Ernest Burkman, Director (1972–)
David D. Redfield, Associate Director (1974–)
William R. Snyder, Associate Director (1974–)
*Robert Vickery, Associate Director (1973–74)

Tedd Arnold (1973–)
Denis Blakeway (1974–)
Calvin E. Bolin (1973–)
Drennen A. Browne (1974–)
*Robert Buchanan (1973–75)
Marcia Bujold (1974–)
*David L. Camp (1973–74)
Gwendie Camp (1974–)
Jerome L. Ciesla (1973–)
Clifton Bob Clark (1975–)
Robert L. Cocanougher (1972–)
Sara P. Craig (1973–)
Stewart P. Darrow (1973–)
*Allan D. Dawson (1972–74)
*Joel Dawson (1972–73)
Gene Floersch (1975–)
*Ronald N. Giese (1974)
Gail M. Grandy (1973–)
James A. Greenwood (1973–)
James P. Hale (1974–)
*Fred Hartford (1974–75)
James A. Hathway (1973–)
Mary Ann Herny (1975–)
Lila T. Kirschbaum (1975–)
Ronald C. Laugen (1973–)
*Francis X. Lawlor (1973–74)
Clarke G. Lieffers (1974–)
Adrian D. Lovell (1972–)
Joan F. Matey (1975–)
Brenda Musgrave-Propst (1975–)
*Gerald Neufeld (1972–74)
*Barney Parker (1973–74)
Marvin D. Patterson (1973–)
Charles E. Peters (1973–)
Susan Reichman (1974–)
Dee Dee Shand (1974–)
Beverly Smith (1974–)
Donald A. Smith (1973–)
*John A. Sumner (1974–75)
*Clifford Swartz (1972–73)
Ralph G. Vedros (1973–)
Thomas Whitworth (1975–)
Lois S. Wilson (1973–)
Jay A. Young (1975–)

*Former member

Writing Conference Participants and Author-Consultants

Betsy Balzano, SUNY, Brockport; David Berey, Roslyn (NY) Schools; Robert Bernoff, Penn. State University; Capt. George Bond, Naval Coastal Systems Laboratory; Ted Bredderman, Delmar, New York; John Cunningham, Keene (NH) State College; James DeRose, Marple-Newtown (PA) School District; Roy A. Gallant, Rangeley, Maine; Orrin Gould, University of Illinois; Francis U. Hackley, Leon (FL) Schools; Jack Hassard, Georgia State University; Robert E. Horvat, SUNY, Buffalo; Stuart J. Inglis, Medford (OR) School District; Jane Kahle, Purdue University; Al Kaskel, Evanston (IL) Schools; David Klasson, Fall River (CA) Joint Unified School District; David Kuhn, Tarrytown (NY) Schools; Clarence T. Lange, Clayton (MO) Schools; Sander Latts, University of Minnesota; Robert L. Lehrman, Roslyn (NY) Schools; Harleen McAda, University of California, Santa Barbara; Wendell Mohling, Shawnee Mission (KS) Schools; Floyd Monaghan, Michigan State University; Rod O'Connor, Texas A & M University; Shirley Richardson, San Diego (CA) Schools; Guenter Schwarz (Deceased); Douglas P. Smith, Florida State University; Claude A. Welch, Macalester College

PACKAGING PASSENGERS

Ginn and Company
A Xerox Education Company

D39506
ISBN 0-663-33761-5